LLAGAS CREEK

RECONNAISSANCE LEVEL STUDIES

PHASES 1 THROUGH 6A

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LLAGAS CREEK

RECONNAISSANCE LEVEL STUDIES

PHASES 1 THROUGH 6A

22 December 1975

LLAGAS CREEK - RECONNAISSANCE INVESTIGATION

SUMMARY OF ALTERNATES

CONTENTS

PART I INTRODUCTION AND PURPOSE

PART II DESCRIPTION OF ALTERNATES

PART III COMPARISON OF ALTERNATES

- A) Summary of Costs
- B) Summary of Non Structural Measures
- C) Advantages and Disadvantages

PART IV ENVIRONMENTAL IMPACTS

PART I

INTRODUCTION

The Llagas Creek watershed contains about 100 square miles and is located in the southern Santa Clara Valley. The topography varies from the Santa Cruz mountainous region, to rolling uplands, to a broad flat valley. Serious flooding has occurred historically in the broad flat valley in which the urbanized communities of Morgan Hill and Gilroy are located.

Both communities have significant growth potential in residential, commercial and industrial development. As development increases, the matter of flood protection becomes more urgent.

Previous studies by the U.S. Department of Agriculture, Soil Conservation Service, developed a Work Plan in 1966 defining extensive structural flood control measures for the Upper and Lower Llagas Creeks including improvements to the existing Chesbro Reservoir. Following the adoption of the Work Plan, a small section of Llagas Creek at its confluence with the Pajaro River was improved in 1972. This section is designated as Reach #1 and is excluded from the scope of this report.

Further construction other than Reach #1 has been deferred because of environmental regulatory requirements and the need to work more closely with citizen objectives and concerns.

In the interim, the State Highway Department (now CALTRANS) excavated several reaches of Llagas Creek in accordance with the 1966 Work Plan. The excavated material was used as a source of borrow for freeway construction. Some land has been acquired in anticipation of further creek improvements, again in accordance with the Work Plan.

Before implementing any further improvements the Sponsors, in conjunction with the Citizens Committee, decided that several alternative programs or variations on the 1966 Work Plan should be considered. Upon selection of an Alternate, a Draft Environmental Impact Statement and revised Work Plan will be prepared.

The sponsoring agencies responsible for implementing further flood control programs are:-

South Santa Clara Valley Water Conservation District, San Jose, California
Santa Clara Valley Water District, San Jose, California
Loma Prieta Resource Conservation District, Morgan Hill, California.

The U.S. Department of Agriculture, Soils Conservation Service, Davis, California provides assistance to the above sponsors.

Citizen concerns are represented by a Citizens Advisory Committee which convenes at Gilroy, generally at monthly intervals.

PURPOSE OF THIS REPORT

The purpose of this report is to examine several possible alternate programs for flood protection and provide information to assist the Sponsors and the Citizens Advisory Committee to select the most desirable alternative.

The Soils Conservation Service requested that the report be divided into five phases as follows:

Phase 1	Channel Alternate - 1% Chance Flood
Phase 2	Levee Alternate - 1% Chance Flood
Phase 3	Clearing Alternate
Phase 4	Channel and Levee Alternate - 10% Chance Flood
Phase 5	Non Structural Alternate
Phase 6	Summary

The five phases are presented as sub-reports following this summary report, which represents Phase 6.

PART II

DESCRIPTION OF ALTERNATES

The five alternates are briefly described as follows:

Phase 1 The Channel Alternate contains the basic proposals of the 1966 Work Plan and is designed for protection from a 1% chance flood. The original plan has been modified by new criteria:

a) The design flows have been increased by varying amounts for each reach. The overall increase is in the order of 5%.

b) Maximum velocities have been curtailed to reduce erosion and generally represent a reduction of about 25%.

Phase 2 The Levee Alternate examines a solution whereby protection from a 1% chance flood is provided by a levee system. The levees are set back from the creek banks a sufficient distance to contain the floodwaters. No improvements are contemplated to the existing creek other than road and bridge crossings, etc.

Phase 3 The clearing alternate is limited to certain designated upper reaches of the creek. Most of the existing channels are narrow and partially blocked by vegetation. The purpose of the study is to investigate the cost and benefits of clearing alone.

Phase 4 The channel alternate and levee alternate are investigated for smaller design flows resulting from a 10% chance flood The investigation is limited to certain designated upper reaches.

Phase 5 Certain non-structural alternates are investigated. These include:

- Land Use Regulation
- Flood Insurance
- Flood Warning
- Flood Preparedness Planning
- Land Acquisition
- Floodproofing
- Tax and Policy Adjustment

PART III

COMPARISON OF COSTS

A. SUMMARY OF COSTS

Detail cost tabulations for each phase and for each reach are included in this summary and in each sub-report. In comparing costs, however, it must be recognized that the various alternatives do not produce identical results. In particular, the degree of flood protection and scope of work varies for different alternates. The cost of a non-structural program is highly variable depending on the program selected and also depending on specific sites within programs. Further, the range of benefits to costs can vary from nominal to extremely large.

For the above reasons and because there is no easy way to compare benefits, the costs of a non structural program have been omitted from the following comparison. Instead a written summary of Phase 5 follows in Part III B.

It should be noted, however, that the directly identifiable costs of a non structural program are generally much less than a structural program, but that there may be larger unidentifiable costs and benefits.

PART III LLAGAS CREEK - SUMMARY OF ESTIMATED COSTS - PHASE 1, CHANNEL ALTERNATE

REACH NO.	CAPITAL COSTS							AVERAGE ANNUAL COSTS			
	INSTALLATION COSTS (566 FUNDS)			OTHER INSTALLATION COSTS			GRAND TOTAL	CAPITAL COSTS AMORTIZED	M & O		TOTAL ANNUAL EQUIVALENT
	Construct	Eng.	Total	Land	Construct	Total			MI.	$	
2	3,002,500	750,600	3,753,100	215,500	293,000	508,500	4,261,600	144,400	2.23	4,500	148,900
3	3,020,100	755,000	3,775,100	388,400	478,900	867,300	4,642,400	157,300	3.73	7,500	164,800
4	2,640,300	660,100	3,300,400	598,700	170,400	769,100	4,069,500	137,900	2.26	4,500	142,400
5	474,500	118,600	593,100	80,300	700	81,000	674,100	22,800	0.45	900	23,700
6a	2,287,900	572,000	2,859,900	790,800	9,800	800,600	3,660,500	124,000	3.44	6,900	130,900
6b	499,100	124,800	623,900	89,200	-	89,200	713,100	24,200	0.59	1,200	25,400
7a	1,343,800	336,000	1,679,800	396,300	116,900	513,200	2,193,000	74,300	1.83	3,700	78,000
7b	303,000	75,800	378,800	158,600	159,200	317,800	696,600	23,600	0.90	1,800	25,400
7c	92,200	23,100	115,300	48,400	-	48,400	163,700	5,500	0.32	600	6,100
8a	787,500	196,900	984,400	26,500	203,200	229,700	1,214,100	41,100	0.97	1,900	43,000
8b	185,300	46,300	231,600	103,700	21,500	125,200	356,800	12,100	0.61	1,200	13,300
9	1,445,800	361,400	1,807,200	822,800	329,600	1,152,400	2,959,600	100,300	3.20	6,400	106,700
10	300,500	75,100	375,600	111,600	358,900	470,500	846,100	28,700	0.49	1,000	29,700
11a	451,000	112,800	563,800	180,400	162,500	342,900	906,700	30,700	0.72	1,400	32,100
11b	728,700	182,200	910,900	236,400	76,200	312,600	1,223,500	41,500	1.45	2,900	44,400
12	586,200	146,600	732,800	248,200	106,000	354,200	1,087,000	36,800	1.70	3,400	40,200
13S	287,700	71,900	359,600	87,100	17,300	104,400	464,000	15,700	0.64	1,300	17,000
13N	186,600	46,700	233,300	46,500	57,100	103,600	336,900	11,400	0.30	600	12,000
14	1,360,300	340,000	1,700,300	731,100	256,400	987,500	2,687,800	91,100	3.41	6,800	97,900
14	595,700	148,900	744,600	23,500	-	23,500	768,100	26,000	0.01	100	26,100
15a	351,600	87,900	439,500	130,300	25,500	155,800	595,300	20,200	0.73	1.500	21,700
15b	347,500	86,900	434,400	307,700	154,700	462,400	896,800	30,400	1.54	3,000	33,400
16	231,200	57,800	289,000	104,700	26,100	130,800	419,800	14,200	0.76	1,500	15,700
	21,509,000	5,377,400	26,886,400	5,926,700	3,023,900	8,950,600	35,837,000	1,214,200	32.88	64,600	1,278,800

LLAGAS CREEK -- SUMMARY OF ESTIMATED COSTS - PHASE 2, LEVEE ALTERNATE

REACH NO.	CAPITAL COSTS							AVERAGE ANNUAL COSTS			
	INSTALLATION COSTS (566 FUNDS)			OTHER INSTALLATION COSTS			GRAND TOTAL	CAPITAL COSTS AMORTIZED	M & O		TOTAL ANNUAL EQUIVALENT
	Construct	Eng.	Total	Land	Construct	Total			MI.	$	
2	1,135,800	284,000	1,419,800	527,100	422,200	949,300	2,369,100	80,300	2.24	1,700	82,000
4	701,600	175,400	877,000	1,849,400	720,400	2,569,800	3,446,800	116,800	2.35	1,700	118,500
6a	918,300	229,600	1,147,900	615,800	0	615,800	1,763,700	59,800	3.47	2,500	62,300
6b	138,200	34,500	172,700	47,900	0	47,900	220,600	7,500	0.70	500	8,000
7a	821,300	205,300	1,026,600	387,500	115,200	502,700	1,529,300	51,800	1.68	1,300	53,100
7b	241,300	60,300	301,600	165,400	306,200	471,600	773,200	26,200	0.66	500	26,700
7c	114,900	28,700	143,600	79,000	0	79,000	222,600	7,400	0.43	300	7,700
10	287,100	71,800	358,900	111,600	393,900	505,500	864,400	29,300	0.49	400	29,700
11a	223,100	55,800	278,900	381,800	311,900	693,700	972,600	33,000	0.76	600	33,600
11b	479,100	119,800	598,900	1,278,600	1,407,600	2,686,200	3,285,100	111,300	1.78	1,300	112,600
12	497,800	124,500	622,300	557,600	645,800	1,203,400	1,825,700	61,900	1.51	1,100	63,000
13	234,100	58,500	292,600	241,400	257,700	499,100	791,700	26,800	0.86	600	27,400
15a	212,800	53,200	266,000	185,900	24,800	210,700	476,700	16,200	0.69	500	16,700
15b	267,700	66,900	334,600	354,800	163,600	518,400	853,000	28,900	1.43	1,100	30,000
16	233,900	58,500	292,400	181,800	26,100	207,900	500,300	17,000	0.88	600	17,600
Subtotal	6,507,000	1,626,800	8,133,800	6,965,600	4,795,400	11,761,000	19,894,800	674,200	19.26	14,200	688,900
Other*	7,869,200	1,967,100	9,836,300	2,176,300	1,290,300	3,466,600	13,302,900	450,700	12.38	24,800	475,500
TOTAL	14,376,200	3,593,900	17,970,100	9,141,900	6,085,700	15,227,600	33,197,700	1,124,900	44.02	39,000	1,164,400

*Reaches 3, 5, 8a, 8b, 9 and 14 which are excavation alternates. See Phase 1 for cost detail.

LLAGAS CREEK - PHASE 3 COST ESTIMATE

Channel Reach No.	Channel Designation		Design Discharge 1% Chance c.f.s.	Existing Capacity c.f.s.	Capacity with Clearing c.f.s.	Length to be Cleared l.f.	Cost of Clearing $
	Begin Sta.	End Sta.					
6a	522+00	605+00	5,400	3,000*	3,000	no benefit	--
	605+00	650+00	5,100	6,500*	6,500	"	
	650+00	703+70	5,100	3,500*	3,500	"	--
6b	703+70	743+00	3,430	3,000to 5,000	3,400to 5,800	3,930	2,000
7a	0+00	75+00	new channel				
	75+00	89+00	1,680	100*	134	1,400	700
7b	96+40	144+00	1,470	100*	150	4,760	2,400
7c	0+00	17+00	465	35*	35	1,700	900
11a	179+50	220+00	2,900	28**	40	4,050	2,000
11b	220+00	314+00	2,700	28**	40	9,400	4,700
12	195+00	287+50	2,000	28**	40	9,250	4,600
13	199+50	233+00	465	56**	84	3,350	1,700
15a	6+50	42+00	1,440	421*	562	3,550	1,800
15b	42+00	78+50	1,440	97*	130	3,650	1,800
	78+50	126+00	1,440	470*	470	4,750	2,400
16	180+50	220+85	810	40*	54	4,035	2,000

* Existing capacity from 1966 Work Plan
** Estimated by DMJM

PART III LLAGAS CREEK - SUMMARY OF ESTIMATED COSTS - PHASE 4A, EXCAVATION ALTERNATE

REACH NO.	CAPITAL COSTS							AVERAGE ANNUAL COSTS			
	INSTALLATION COSTS (566 FUNDS)			OTHER INSTALLATION COSTS			GRAND TOTAL	CAPITAL COSTS AMORTIZED	M & O		TOTAL ANNUAL EQUIVALENT
	Construct	Eng.	Total	Land	Construct	Total			MI.	$	
11a	352,100	88,000	440,100	152,200	114,900	267,100	707,200	24,000	0.767	600	24,600
11b	576,300	144,100	720,400	201,800	53,300	255,100	975,500	33,000	1.780	1,300	34,300
12	583,400	145,900	729,300	217,200	51,600	268,800	998,100	33,900	1.515	1,100	35,000
13	341,600	85,400	427,000	111,100	23,000	134,100	561,100	19,000	.862	700	19,700
15a	278,900	69,700	348,600	101,900	25,500	127,400	476,000	16,100	.694	500	16,600
15b	319,000	79,700	398,700	199,900	152,200	352,100	750,800	25,400	.763	600	26,000
16	161,300	40,300	201,600	86,700	16,500	103,200	304,800	10,300	.863	600	10,900
TOTAL	2,612,600	653,100	3,265,700	1,070,800	437,000	1,507,800	4,773,500	161,700	7.244	5,400	167,100
SAME REACHES PHASE 1 TOTAL	3,170,500	692,800	3,963,300	1,341,300	625,400	1,966,700	5,930,000	200,900	7.840	15,600	2,165,500

LLAGAS CREEK - SUMMARY OF ESTIMATED COSTS - PHASE 4B, LEVEE ALTERNATE

REACH NO.	CAPITAL COSTS							AVERAGE ANNUAL COSTS			
	INSTALLATION COSTS (566 FUNDS)			OTHER INSTALLATION COSTS			GRAND TOTAL	CAPITAL COSTS AMORTIZED	M & O		TOTAL ANNUAL EQUIVALENT
	Construct	Eng.	Total	Land	Construct	Total			MI.	$	
11a	220,500	55,100	275,600	242,700	168,400	411,100	686,700	23,300	0.76	600	23,900
11b	463,000	115,800	578,800	850,100	844,600	1,694,700	2,273,500	77,000	1.78	1,300	78,300
12	480,200	120,100	600,300	509,400	436,100	945,500	1,545,800	52,400	1.51	1,100	53,500
13	215,000	53,800	268,800	166,900	210,900	377,800	646,600	21,900	0.86	600	22,500
15a	210,400	52,600	263,000	297,100	18,800	315,900	578,900	19,600	0.69	500	20,100
15b	276,600	69,200	345,800	235,200	140,500	375,700	721,500	24,400	1.43	1,100	25,500
16	230,200	57,500	287,700	169,500	18,800	188,300	476,000	16,100	0.88	600	16,700
TOTAL	2,095,900	524,100	2,620,000	2,470,900	1,838,100	4,309,000	6,929,000	234,700	7.24	5,800	240,500
SAME REACHES PHASE 2 TOTAL	2,148,500	537,200	2,685,700	3,181,900	2,837,500	6,019,400	8,705,100	295,100	7.24	5,800	300,900

B. SUMMARY OF NON STRUCTURAL MEASURES

Numerous types of non structural measures may be used as a supplement or alternative to structural measures. They differ from structural measures in several significant aspects including their concept, the nature and distribution of their costs and benefits, the type and extent of protection provided and in other ways. Non structural measures are generally far less expensive to implement than structural measures and many of them can be put into effect quickly. Additionally, non structural measures often do not foreclose other action at a later date. In some cases, non structural measures may complement open space or diverse other objectives.

The evaluation of the applicability of non structural measures in the Llagas Creek watersheds considered flood insurance, floodproofing, flood forecasting and warning, preparedness planning, land use and other regulatory programs, acquisition, and adjustments in taxing and other policies.

Of the eleven stream reaches evaluated individually for non structural programs, Reaches 6b and 7c appear candidates for non structural regulatory programs in lieu of any structural solution.

Recommendations for Regional Programs are:

1. improvement of the existing flood forecasting and warning system throughout the project area;
2. development of a specific flood preparedness plan for the project area;
3. implementation of an effort to give specific attention to the use of policy tools by local governments to mitigate flood losses.

In addition, it is recommended that consideration be given to the periodic updating of flood risk information as the installation of structural measures proceeds to provide a basis for adjusting participation in the flood insurance program and related rates.

C. ADVANTAGES AND DISADVANTAGES

A summary of the broad advantages and disadvantages of each alternate is listed in the table below. We have not made any specific recommendations, as the final evaluation and selection will be made by the Sponsors with recommendations from the Citizens Committee.

It may well be that a combination of several alternates will be the most desirable, depending on the characteristics of each individual reach. In any event, inclusion of some non structural measures should be incorporated in the revised Work Plan. We believe, however, that the level of detail currently shown in Part V of this report should be sufficient for work plan purposes.

ALTERNATE	ADVANTAGES	DISADVANTAGES
Phase 1 **CHANNEL**	1% Chance Flood Protection with minimal land acquisition. Lower water surface improves local side drainage inlet duration. Velocity control minimizes erosion.	Highest construction cost of all alternatives. Greatest ecological impact.
Phase 2 **LEVEE**	1% Chance Flood Protection with less cost than Phase 1. Less ecological impact than Phase 1 and 4.	Highest land acquisition cost of all alternatives. Limited amount of velocity control and erosion protection. LARGER LOCAL BURDEN! The current apparent economic advantages of this plan may be lost with a rapid escalation of future land values prior to property acquisition.
Phase 3 **CLEARING**	Low cost. Easy to implement. No land acquisition. Least ecological impact.	Ineffective for major flood protection. Annual maintenance program essential. Maintenance costs may be of similar magnitude to initial clearing costs.
Phase 4 **CHANNEL AND LEVEE** **10% PROTECTION**	Lower cost than Phase 1 and Phase 2 Alternates. Lesser degree of environmental impact than Phase 1 and Phase 2 Alternates.	Reduced level of flood protection in upper reaches. High construction cost.
Phase 5 **NON STRUCTURAL**	Low cost May be implemented by stages. May be an alternative or supplemental to a structural program. Very flexible.	Level of protection lower than structural alternates. Controversial issues may be raised during implementation. Long term administration may be a problem. Program subject to political revisions at any time without regard to original long term goals.

PART IV

ENVIRONMENTAL IMPACTS

Environmental mitigation measures are included in sub-reports for Phases 1 through 4.

The summary matrix of environmental impacts which follows illustrates the comparative severity of impacts between alternates.

In general, maximum impacts are related to the channel alternate, less severe impacts relate to the levee solution, and minimal impacts occur with clearing only.

The matrix does not attempt to differentiate between major and minor impacts as in many cases the impacts are difficult to quantify. The following discussion does identify some major and minor impacts and explains why impacts are considered beneficial or adverse.

TOPOGRAPHY

The topography affected by the channel is composed of coalesced alluvial fans sloping gently upward from the broad, nearly flat valley floor to the mountain ranges on either side of the valley. Within the main portion of the valley Llagas Creek and its tributaries are the dominant features. Obviously, any changes in the present configuration or alignment of the creek are going to have an effect upon the topography of the valley floor. These impacts are considered potentially adverse with the excavation alternate because of abandonment of small sections of creek beds. The levee alternates will result in minor changes in topography along the creek banks which will result in minor visual impacts.

EARTH PROCESSES

Erosion in the stream bed is currently taking place and will continue to some extent regardless of which channel improvement alternate is implemented. The potential for erosion is greater under the levee and clearing alternate than under the excavation alternate.

The potential for flooding is, of course, reduced under each alternate. This is beneficial in respect to protection of life and property, but potentially adverse in respect to the reduction of sedimentation which enriches the farmlands.

GEOLOGIC HAZARDS

Improvement of Ilagas Creek under any of the alternates probably will not affect or be affected by the present geologic conditions of the valley. No active earthquake faults are known to traverse the project area. Soils conditions would appear to preclude ground failure from liquefaction, landsliding or other movements induced by siesmic shaking.

NATURAL RESOURCES

Two kinds of natural resources are present in any area: the land itself, and the material underlying the land. The impacts associated with the proposed project are considered both potentially adverse and beneficial and long term. They include:

a) Beneficial - Protection of flood plane area from flooding
b) Adverse - Elimination of natural soil enrichment process situation
c) Beneficial - Reduction in soil and mineral losses through erosion
d) Adverse - Reduction in groundwater recharge capability (alternates 1 and 3)

GROUNDWATER

Almost all of the South County water supply comes from groundwater. It is our opinion that the proposed improvements will not greatly affect the existing percolation areas unless erosion and sedimentation are substantially increased in the excavation solution. The levee concept would leave the channel in its existing condition and would result in minor changes in the vicinity of the channel.

WATER QUALITY

Water quality of the Creek will be effected adversely on a short term basis during or following the construction period due to an increase in sedimentation. The levee solution will result in minor changes of water. The quality potential exists for long term adverse impacts, associated with the excavation and clearing alternates, in the nature of a reduction in quality from shallower flows, increased turbidity, loss of shade and loss or reduction of streamside vegetation.

RIPARIAN HABITAT

Channel improvements under alternates 1 and 3 will have significant long term adverse impacts upon riparian habitats with the most severe occuring under alternate 1. Loss or reduction of shore line vegetation will cause extensive loss of wildlife through attrition or abandonment of habitat due to loss of cover, food, shade and nesting areas including possible elimination of certain species, reduction of poprilation of remaining species and possible introduction of non-native species.

Short term impacts may occur in the nature of disruptions in the serenity of wildlife habitats during construction of the levees under alternate 2.

OTHER NATURAL VEGETATION

In areas where channelization occurs in the existing creekbed, all vegetation within a 300 foot-wide swath would be removed. The construction program under any of the 3 alternates would cause damage to adjacent vegetated areas. The most severe impacts to adjacent vegetated areas would probably occur with the levee alternate during flood stage.

BIRDLIFE AND OTHER RIPARIAN WILDLIFE

The removal of riparian vegetation will have a significant, long-term, adverse impact upon the various species of birds and other wildlife whose survival depends upon the vegetation for food, shelter, and nesting areas.

FISH HABITAT

Excavation of the creek would dramatically change the characteristics of the creek by eliminating pools and shallows and migratory pathways thus reducing the fish population and possibly eliminating some species. Impacts would be somewhat less severe under the clearing alternate but still existent. The levee alternate is not expected to affect the fishlife in any manner.

CAN BE INCLUDED BY PROPER DESIGN

AIR QUALITY

Construction associated with any of the alternates will have a short-term adverse impact upon air quality in the form of vehicle and machinery emissions and dust particles. Upon completion of the construction program, no further impacts upon air quality are anticipated.

NOISE

The dominant source of noise in the project area is vehicular traffic. The current noise environment is thus closely linked to the daily variation in traffic volumes and proximity to traffic arteries. In a few areas, where agricultural operations and resident uses are located close together, agricultural machinery may cause localized noise level problems.
Operation of machinery during the construction phase of any of the proposed alternatives will increase ambient noise levels but this will be a short-term, although adverse impact.

ADJACENT LAND USE

The predominant land use within the project area is agricultural, although the urban centers are reflecting the impact of urban growth due to their proximity to San Jose. Severe adverse impacts can be expected for alternatives 1 and 2 in the nature of:

a) Loss of land for right-of-way acquisitions

b) Induced land-use changes brought about by flood protection

c) Loss of jobs, directly or indirectly from reduction of agricultural activities

OPEN SPACE: PARKS AND RECREATION

All three improvement alternates will impose potentially long-term adverse impacts on the open space element in the nature of the loss of natural open space value, existing creekside recreational potential and reduction in game fish and wildlife.

ECONOMIC BASE

The proposed project would have potentially beneficial impacts on the project area in the nature of:

a) Urban damage prevention through flood protection

b) Agricultural damage prevention

c) Increase in disposable incomes

d) Project-created jobs

e) Increased business for local suppliers caused by the project

The potential also exists for increased maintenance costs or degredation of public investment from failure of project to perform as expected. This could present a long-term adverse impact.

INDUCED GROWTH

The project related growth-inducing impacts are considered potentially both adverse and beneficial and long term. It is impossible to project the comparative severity or magnitude of impacts but, in general, they include:

a) Adverse - Increased urbanization bringing the problems of pollution, traffic congestion and increased burden on public facilities.

b) Beneficial - Increased urbanization providing jobs, stimulating the local economic community and raising the standard of living.

c) Adverse - Elimination or reduction of potential flood threat within the flood plain.

d) Beneficial - Change in land use from agricultural due to elimination or reduction in flood threat.

e) Adverse - Impact upon flora and fauna of the area due to increased urbanization.

f) Adverse - Reduction in quality of ground water and creek due to increased runoff from urbanized areas.

g) Adverse - Degradation of visual and aesthetic values through increased population.

HEALTH AND SAFETY

Impacts related to health and safety aspects of alternates 1 and 2 are deemed potentially beneficial and long term in that flood prevention must reduce the hazards to life and property. Alternate 3 would not provide the protection of alternate 1 and 2.

VISUAL AND AESTHETIC

The impacts on visual and aesthetic qualities are considered to be potentially adverse and long term. They include:

a) Conflict with County Parks Plan for Llagas Creek Park Chain
b) Loss of channel access
c) Loss of existing streamside visual and aesthetic amenities
d) Creation of landscape scars
e) Loss of creekside recreational potential
f) Conflict with County Urban Development/Open Space Plan

There will also be short-term adverse impacts associated with the construction program.

HISTORIC AND ARCHEOLOGICAL RESOURCES

Long term, potentially adverse impacts will be caused by alternates 1 and 2 in the nature of:

a) Loss of a few historic resources alongside the Creek.

b) Potential loss of other archeological and historic resources due to project-induced urban growth.

ACCESS PATTERNS AND TRAFFIC CIRCULATION

Potentially adverse, short-term impacts are expected to be experienced during the construction program.

DISPLACEMENT/PRE-EMPTION OF USES OR USERS

Channel improvement alternates 1 and 2 are expected to produce potentially adverse, long term impacts in the nature of:

a) Removal of land from present use through right-of-way acquisition.

b) Loss of potential recreational use through denied access to the creek.

c) Land use changes brought about by project-induced urban growth.

IMPACT MATRIX

○ POTENTIALLY BENEFICIAL
■ POTENTIALLY ADVERSE (LONG TERM)
▪ POTENTIALLY ADVERSE (SHORT TERM)

		1 CHANNEL ALTERNATE 1% CHANCE	2 LEVEE ALTERNATE 1% CHANCE	3 CLEARING ALTERNATE	4a CHANNEL ALTERNATE 10% CHANCE	4b LEVEE ALTERNATE 10% CHANCE
PHYSICAL ENVIRONMENT	Topography	■	■		SAME AS PHASE 1	SAME AS PHASE 2
	Earth Processes	▪ ○		■		
	Geologic Hazards					
	Natural Resources	■ ○	■ ○	■ ○		
	Groundwater	■				
	Water Quality	▪		▪		
	Riparian Habitat	■	▪	■		
	Other Natural Vegetation.	▪	▪			
	Birdlife	■	▪	■		
	Other Riparian Wildlife	■		■		
	Fish Habitat	■		▪		
	Migratory Pathway	■				
	Air Quality	▪	▪	▪		
	Noise	▪	▪	▪		
SOCIAL ENVIRONMENT	Adjacent Land Use	■	■			
	Open Space: Parks & Recreation	■	■	■		
	Economic Base	○	○			
	Induced Growth	■ ○	■ ○	○		
	Health & Safety	○	○			
	Visual & Aesthetic	■	▪	▪		
	Historic & Archeological Resources	■	■			
	Access Patterns & Traffic Circulation	▪	▪			
	Displacement/Pre-emption of Uses or Users	■	■			

LLAGAS CREEK

RECONNAISSANCE INVESTIGATION

(PHASE 1)

CHANNEL ALTERNATE - 1% CHANCE

22 DECEMBER 1975

LLAGAS CREEK - RECONNAISSANCE INVESTIGATION

PHASE 1 CHANNEL ALTERNATE 1% CHANCE

CONTENTS

PART I	GENERAL DISCUSSION
PART II	PROCEDURES AND ASSUMPTIONS
PART III	SUMMARY OF ESTIMATED COSTS (including notes)
PART IV	ENVIRONMENTAL MITIGATION AND LANDSCAPING MEASURES
PART V	SUPPORTING INFORMATION
	a) Plan of Reaches and Stationing System
	b) Hydraulic Design Summary
	c) Typical Sections - Trapezoidal and Rectangular Channels
	d) Right of Way Summary Table

PART I

GENERAL DISCUSSION

SCOPE

The investigation for the Channel Alternate is based on the watershed Work Plans for the Upper and Lower Llagas Creek prepared by the Soil Conservation Service in 1966. The investigation takes into account criteria for increased peak flows and lower maximum design velocities. The criteria was furnished by SCS. The investigation includes the preparation of a comparative cost estimate in 1975 dollars and a discussion of environmental mitigation and landscaping measures.

CONCEPT

The Channel Alternate is essentially a solution which provides flood protection by excavating the existing creek to form a channel of sufficient size to accommodate the peak flows within the confines of the improved channel. Erosion protection is provided by limiting maximum velocities to acceptable values for existing soil conditions encountered in the various reaches and by landscaping measures. For noncohesive soils, riprap protection is provided along the creek banks.

Velocity control is obtained by flattening the longitudinal slope of the channel and the installation of vertical drop structures at strategic points on the channel alignment.

Changes in creek alignment to straighten channels and some diversions of flow were proposed in the 1966 Work Plan. Such proposals are unchanged.

Channel crossings for public and private roads and railroad are in the locations described in the 1966 Work Plan.

REACH DESIGNATION AND STATIONING

For convenience of investigation, the Upper and Lower Llagas Creek and the principal tributaries have been divided into reaches. A key plan showing the designated reaches is included in Part V of this report.

PRIOR WORK BY OTHERS

When the freeway (Highway 101 bypass of Morgan Hill and Gilroy) was constructed in 1971 by the then State Division of Highways, some creek excavation was performed to develop borrow areas for highway embankment material. Reaches 3, 5, 9 and 14 were excavated to the widths and depths indicated on the 1966 Work Plan. The work did not include excavation for proposed bridge structures and drop structures within the above reaches.

CHANNEL SECTION

The proposed channel section is typically trapezoidal as shown on the sketch included in Part V of this report. Maintenance access strips, 18 feet wide, are provided on each bank. The right of way requirement includes space for a shallow interceptor ditch outboard of the access strip to collect stormwater from local runoff.

An exception to the typical solution is the rectangular concrete lined channel proposed for Reach 8a. Reach 8a is an urban area and the width of a standard trapezoidal section would be impractical. Maintenance access for Reach 8a is assumed to be along the channel floor with access points at street crossings.

PART II

PROCEDURES AND ASSUMPTIONS

ALIGNMENT STATIONING

The alignment and stationing used for this study is the same as shown in the Work Plan Engineering and Geologic Appendices dated April 1966.

SOILS

Limits of cohesive and noncohesive soils are as defined by the Government. Grain sizes for noncohesive soils are as shown in the 1966 Work Plan.

CHANNEL DESIGN - GENERAL

1. Hydraulic criteria used in the design are as follows:

   a) Values of Q for the 1% chance flood are as furnished by the Government.

   b) Maximum allowable velocities furnished by the Government are 6.0 f.p.s. for cohesive soils and according to Fig. 6.1 (Curve 1) Technical Release No. 25 for noncohesive soils.

c) A value of n = 0.035 is used for all reaches (estimated per Engineering Handbook Section 5, Supplement B). In addition, the channel design in noncohesive reaches was tested for a 10 percent flood using a value of n = 0.025. In all cases the velocity did not exceed the allowable maximum.

d) Flow calculations are based on the Manning formula applied in accordance with SCS National Engineering Handbook Section 5.

2. Cross sections are typically trapezoidal with a b/d ratio of 10. A freeboard height of 0.2 specific energy is provided above the design water surface. Some compacted embankment is required to contain the floodwater at occasional low points in the ground profile.

CHANNEL LININGS

Channels in cohesive soils are unlined except riprap is provided at channel bends and structures. Channels in noncohesive soils are lined with riprap, minimum thickness of 12 inches increasing to 24 inches. Riprap extends three feet below the channel bottom and one foot above the water surface. Nine inches of filter material is provided under all riprap.

All?

SEEDING

For riprap channels, the remaining unlined freeboard will be seeded.

For unlined channels with bottom width less than 25 feet, the entire periphery is seeded.

For bottom widths exceeding 25 feet, the side slopes and 7.5 foot wide strips adjacent to the bottom will be seeded.

GRADE STABILIZATION STRUCTURES

Grade stabilization structures are provided to reduce channel slopes and control velocities. Additional structures are required above those shown on the 1966 design to meet the new SCS requirement for reduced design velocity.

DRAINAGE INLETS

The number of drainage structures as shown on the 1966 Work Plan appendix have been increased in proportion to the increased design flow.

BRIDGES AND CULVERTS

Bridges and culverts are assumed to be in the location shown in the 1966 Work Plan appendix.

MISCELLANEOUS ITEMS

Miscellaneous items are as shown in the 1966 Work Plan appendix.

RIGHT OF WAY REQUIREMENTS

Right of way requirements include the estimated width of channel plus an 18 foot wide maintenance access road on each side of channel and a collector ditch. Provision is made for a compacted earth berm where required for adequate freeboard. A summary of right of way requirements is included in Part V.

BASIS FOR QUANTITY MEASUREMENT AND COST ESTIMATES

Channel Excavation is the estimated volume of excavation to complete the project and excludes excavation by others prior to 1975. The unit cost includes removal and disposal.

Grade Stabilization Structures are measured as cubic yards of structural concrete using quantities shown in the 1966 Work Plan increased to reflect the additional number of structures, the increased vertical drop, and an overall proportion increase based on the increased design flow. The unit cost price includes all structural items.

Channel Riprap and Filter Stone is measured in cubic yards based on computed sections for increased design flow. For cohesive soils, riprap for special locations is taken from the 1966 Work Plan. The unit cost price includes cost of material and placing.

Bridges are measured in square feet of deck. Bridge quantities for each reach have been increased to reflect an increase in span length. For a rough estimate, work plan quantities have been multiplied by the square root of the increased design flow divided by the work plan design flow. The unit cost price includes foundations and support structure.

Culverts are measured in cubic yards of concrete. Quantities have been increased in direct proportion to the increase in design flow for each reach. The unit cost includes all structural work.

Channel Seeding is measured in acres according to specifications.

Drainage Inlets are measured as a unit. The 1966 cost per unit has been escalated to 1975 prices.

Other miscellaneous items have been price escalated to 1975 dollars.

Right of Way estimates are based on average estimated widths for each reach. Unit prices for land acquisition were furnished by the Santa Clara Valley Water District.

Maintenance Road Surfacing was not required in the 1966 Work Plan and therefore is not included.

PART III

SUMMARY OF ESTIMATED COSTS

GENERAL NOTES

CAPITAL COSTS

Installation Costs (566 Funds)

a) Engineering and Administration costs as tabulated represent 25% of construction. Landscaping costs are included.

Other Installation Costs

a) Land costs include 15% allowance for administration. Total costs include a current value of $2,110,000 for land already purchased.

b) Construction costs include 25% for Engineering and Administration.

AVERAGE ANNUAL COSTS

a) Capital costs are amortized using a factor of 0.03388 based on a rate of 3¼% for a 100 year period. The rate of 3¼% corresponds to the Federal Project Evaluation Rate for 1968.

b) Costs for routine channel maintenance are estimated at $2,000 per mile per year.

PART III LLAGAS CREEK - SUMMARY OF ESTIMATED COSTS - PHASE 1, CHANNEL ALTERNATE

REACH NO.	CAPITAL COSTS							AVERAGE ANNUAL COSTS			
	INSTALLATION COSTS (566 FUNDS)			OTHER INSTALLATION COSTS			GRAND TOTAL	CAPITAL COSTS AMORTIZED	M & O		TOTAL ANNUAL EQUIVALENT
	Construct	Eng.	Total	Land	Construct	Total			MI.	$	
2	3,002,500	750,600	3,753,100	215,500	293,000	508,500	4,261,600	144,400	2.23	4,500	148,900
3	3,020,100	755,000	3,775,100	388,400	478,900	867,300	4,642,400	157,300	3.73	7,500	164,800
4	2,640,300	660,100	3,300,400	598,700	170,400	769,100	4,069,500	137,900	2.26	4,500	142,400
5	474,500	118,600	593,100	80,300	700	81,000	674,100	22,800	0.45	900	23,700
6a	2,287,900	572,000	2,859,900	790,800	9,800	800,600	3,660,500	124,000	3.44	6,900	130,900
6b	499,100	124,800	623,900	89,200	-	89,200	713,100	24,200	0.59	1,200	25,400
7a	1,343,800	336,000	1,679,800	396,300	116,900	513,200	2,193,000	74,300	1.83	3,700	78,000
7b	303,000	75,800	378,800	158,600	159,200	317,800	696,600	23,600	0.90	1,800	25,400
7c	92,200	23,100	115,300	48,400	-	48,400	163,700	5,500	0.32	600	6,100
8a	787,500	196,900	984,400	26,500	203,200	229,700	1,214,100	41,100	0.97	1,900	43,000
8b	185,300	46,300	231,600	103,700	21,500	125,200	356,800	12,100	0.61	1,200	13,300
9	1,445,800	361,400	1,807,200	822,800	329,600	1,152,400	2,959,600	100,300	3.20	6,400	106,700
10	300,500	75,100	375,600	111,600	358,900	470,500	846,100	28,700	0.49	1,000	29,700
11a	451,000	112,800	563,800	180,400	162,500	342,900	906,700	30,700	0.72	1,400	32,100
11b	728,700	182,200	910,900	236,400	76,200	312,600	1,223,500	41,500	1.45	2,900	44,400
12	586,200	146,600	732,800	248,200	106,000	354,200	1,087,000	36,800	1.70	3,400	40,200
13S	287,700	71,900	359,600	87,100	17,300	104,400	464,000	15,700	0.64	1,300	17,000
13N	186,600	46,700	233,300	46,500	57,100	103,600	336,900	11,400	0.30	600	12,000
14	1,360,300	340,000	1,700,300	731,100	256,400	987,500	2,687,800	91,100	3.41	6,800	97,900
14	595,700	148,900	744,600	23,500	-	23,500	768,100	26,000	0.01	100	26,100
15a	351,600	87,900	439,500	130,300	25,500	155,800	595,300	20,200	0.73	1.500	21,700
15b	347,500	86,900	434,400	307,700	154,700	462,400	896,800	30,400	1.54	3,000	33,400
16	231,200	57,800	289,000	104,700	26,100	130,800	419,800	14,200	0.76	1,500	15,700
	21,509,000	5,377,400	26,886,400	5,926,700	3,023,900	8,950,600	35,837,000	1,214,200	32.88	64,600	1,278,800

PART IV

ENVIRONMENTAL MITIGATION AND LANDSCAPING MEASURES

The environmental impacts derived from the channel alternate (Phase 1) are as set forth in the Impact Matrix that follows. The following material identifies possible mitigation measures that can be employed to reduce or eliminate some of the potentially adverse impacts (both short and long term) resulting from this action.

EARTH PROCESSES

- Long range stream erosion in the channels will be reduced through flatter stream bed slopes, rock lining (riprap) of erodible channel banks, vegetative planting of all channel banks not lined, and the use of permanent drop structures.

HYDROLOGY

- Avoid disturbance of channel bottom percolation zone(s) to prevent damage to prime groundwater recharge areas.

WATER QUALITY

- During construction, the contractor should be required to operate and maintain all facilities and equipment required to maintain the quality of water flowing through the work site. Spills of petroleum products and/or chemicals should be avoided.

- The drop structures and other features included to mitigate the bank erosion problem (above) will reduce velocity and increase detention time and will mitigate against lower water temperature and improve dissolved oxygen content. Replacement of shading vegetation will restore loss of habitat for shade seeking creek wildlife.

ECOLOGY

- Extensive loss of wildlife habitat will be mitigated to a certain extent by a channel planting and landscaping program. A planting program, if prepared as part of the design procedure, will provide for planting locations and appropriate landscaping measures, wherever appropriate. Full consideration will be given to use of native and riparian compatible trees, shrubs, vines, and grasses, for wildlife food and replanting success.

- Operation of Chesbro Reservoir for low flow in all or part of Llagas Creek during summer and fall months will help maintain fish habitat.

- Installation of a "low flow" inner channel will concentrate low flows and provide an adequate depth to allow passage of migrating fish.

- Installation of fish ladders at all drop structures in the main channel will permit passage of migrating fish.

AIR QUALITY

- Short term decrease in air quality due to construction dust generation and vehicle emissions can be mitigated to a certain extent by limiting the transportation of materials and/or equipment to designated roads or areas. Dust can be minimized by clean up, sprinkling, or other acceptable practices.

RECREATION

- The loss of "natural" open space value and the loss of existing creekside recreational potential is mitigated in a sense by the creation of public ownership with increased potential access rights to the creek for some recreational uses.

VISUAL AND AESTHETIC

- The measures proposed to mitigate losses of riparian habitat will also serve to alleviate some loss of visual and aesthetic amenities, by restoring native vegetation to the maximum extent possible along the excavated channel. Maintenance policies allowing vegetative growth to remain in the stream bed and on the banks are also necessary to preserve visual amenities.

HISTORICAL AND ARCHEOLOGICAL RESOURCES

Every effort will be made to preserve the Virgil Moniz house and its grounds in Morgan Hill. If the house cannot be saved, a detailed architectural and archeological study of the premises should be conducted prior to construction.

Prior to construction, sample excavations should be undertaken at the three possible prehistoric sites in the section of Llagas Creek south of San Martin to Buena Vista Avenue. Based on this determination, salvage excavations will be provided. Archeological salvage will be done in consultation with the National Park Service.

LANDSCAPE CONCEPT

The natural creek channel has developed over years of interaction between water, soil, plant and weathering process. Generally the creek is uneven and natural, having a variety of tree groves and plant masses. There is an inherent sense of visual continuity to the natural creek.

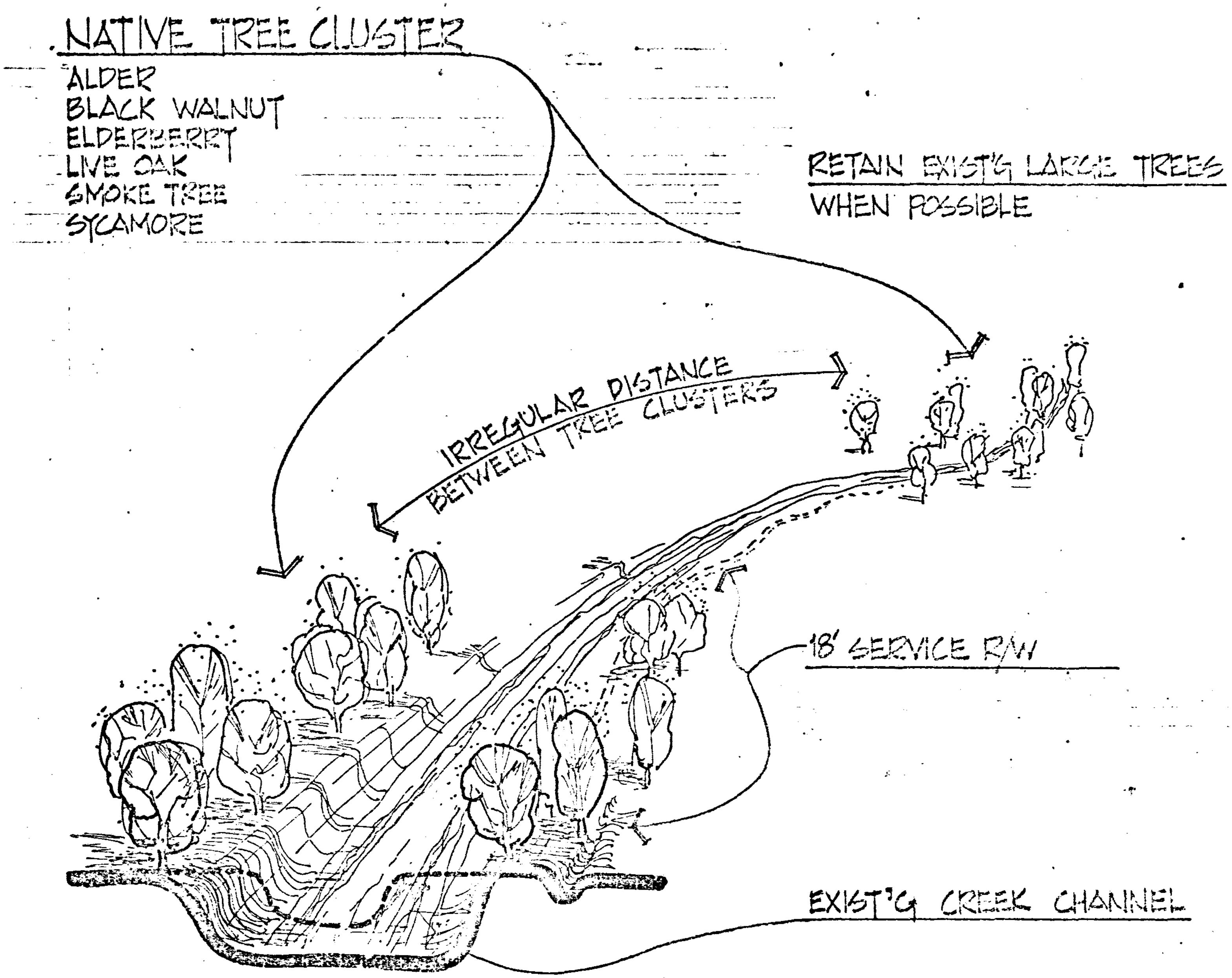
The proposed creek channelization will create a sudden change to the creek bed, creek edges and surrounding environment. In order to provide environmental mitigation and landscaping measures, general landscape concepts have been developed.

1. Retain as many major trees and plant masses as possible. The large tree groves and plant masses are key elements of both the intimate and distant visual landscape.

2. Plant large clusters of trees at all public road crossings and along the creek where it parallels public roads. The tree and plant masses will screen the newly constructed channels and ultimately create a pleasant, natural and spacial experience in the public areas.

3. Plant tree clusters at random distances along the new channels. The tree groves will visually tie the creek into the surrounding landscape, creating a natural environment.

4. Allow native wildflowers, grasses and shrubs to be re-established along the new channel.



LANDSCAPE CONCEPT
EXCAVATED CHANNEL
LLAGAS CREEK

PART V

SUPPORTING INFORMATION

LLAGAS CREEK

KEY PLAN

PHASE # 1 - EXCAVATION ALTERNATE

REACHES & STATIONING SYSTEM

HYDRAULIC DESIGN SUMMARY TABLE - PHASE 1

EXPLANATION OF SYMBOLS

C = Cohesive soil

NC = Noncohesive soil

Q = Design storm flow in cubic feet per second

D75 = Soil grain size 75% percentile

V = Average water velocity in feet per second

A = Effective channel cross sectional area in square feet

d = Depth of water in feet

b = Width of channel bottom in feet

p = Wetted perimeter of channel in feet

r = Hydraulic radius of channel

s = Slope of channel in feet per foot

LLAGAS CREEK – PHASE I – EXCAVATION ALTERNATE HYDRAULIC DESIGN SUMMARY

CHANNEL REACH NO.	STATION DESIGNATIONS		SOIL TYPE C. = COHESIVE NC = NONCOHESIVE	Q DESIGN CAPACITY (C.F.S.)	D_{75} (INCHES)	V (FT/SEC.)	A (FT^2)	d (FT)	b (FT)	P	r	s
	START	END										
	LOWER LLAGAS CREEK											
1	0+00	30+00	C	10,000	—							
	30+00	47+50	C	14,000	—							
	47+50	64+00	C	13,900	—							
2	64+00	93+00	C	13,900	—	6	2,317	14	140	201	11	0.0007
	93+00	121+00	C	17,100	—	6	2,683	15	150	217	12	0.0007
	121+00	127+40	C	17,100	—	6	2,683	15	150	217	12	0.0007
	127+40	150+00	C	16,300	—	6	2683	15	150	217	12	0.0007
	150+00	160+00	C	16,300	—	6	2,683	15	150	217	12	0.0007
	160+00	182+00	N.C.	16,300	0.75	6	2,683	15	150	217	12	0.0007
3	182+00	190+80	N.C.	16,300	0.75	4.65	3,462	17	170	246	14	0.0004
	190+80	294+00	N.C.	10,100	1.00	5	1,860	12	120	176	11	0.0005
	294+00	379+00	C.	9,300	—	6	1,550	12	120	171	9	0.0009
4	379+00	386+00	C	9,300	—	6	1,550	12	120	172	9	0.0010
	386+00	420+00	N.C.	8,900	1.25	5.4	1,648	12	120	172	10	0.0008
	420+00	441+00	N.C.	8,900	0.50	3.8	2,342	14	140	202	12	0.0003
	441+00	458+00	N.C.	8,900	2.60	7.4	1,202.7	10	100	145	8	0.0020
	UPPER LLAGAS CREEK											
	458+00	498+15	NC	8,900	2.60	7.4	1,202.7	10	100	145	8	0.0020
5	498+15	513+00	N.C.	5,400	1.50	5.6	964	9	90	130	7	0.0012
	513+00	522+00	N.C.	5,400	2.00	6.4	844	9	90	130	7	0.0018
6a	522+00	580+00	N.C.	5,400	2.00	6.4	844	9	90	130	6	0.0018
	580+00	650+00	N.C.	5,100	2.00	EXISTING CHANNEL IS ADEQUATE						
	650+00	687+00	N.C.	5,100	2.00	6.4	797	9	90	130	6.4	0.0018
	687+00	703+70	N.C.	5,100	2.00	6.4	797	9	90	130	6.4	0.0018
6b	703+70	724+50	N.C.	3,430	2.00	6.4	536	7	70	101	5.3	0.0025
	724+50	735+00	N.C.	3,430	2.00	6.4	536	7	70	101	5.3	0.0025
	WEST LITTLE LLAGAS CREEK											
7a	0+00	11+50	N.C.	2,160	0.40	3.9	554	7	70	101	5.4	0.0010
	11+50	46+50	N.C.	2,160	0.40	3.9	554	7	70	101	5.4	0.0010
	46+50	75+50	C.	2,160	—	6	360	6	60	87	5	0.0024

DESIGNED BY: N. ZAGHI

LLAGAS CREEK - PHASE 1 - EXCAVATION ALTERNATE HYDRAULIC DESIGN SUMMARY

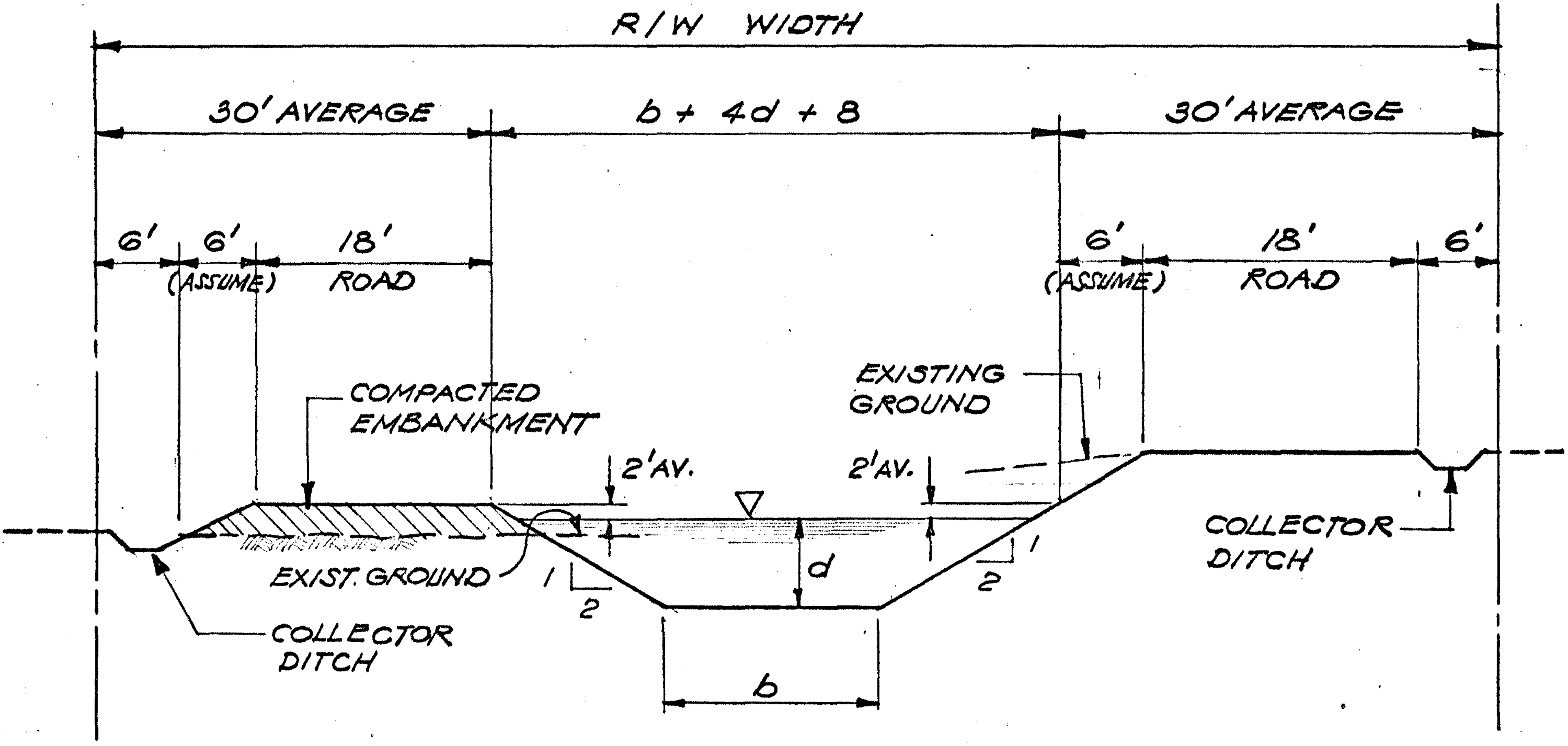
CHANNEL REACH NO.	STATION DESIGNATIONS START	STATION DESIGNATIONS END	SOIL TYPE C = COHESIVE NC = NONCOHESIVE	Q DESIGN CAPACITY (C F S)	D_{75} (INCHES)	V (FT/SEC)	a (FT²)	d (FT)	b (FT)	p	r	s
7a	75+50	96+40	C	1680	—	6	280	5	50	72	4	0.003
7b	96+40	130+20	C	1,470	—	6	245	5	50	72	4	0.003
	130+20	144+00	C	1,300	—	6	216	5	50	72	4	0.003
	EDMUNDSON CREEK											
7c	0+00	17+00	C	465		6	77.5	3	30	43	2.5	0.003
	WEST LITTLE LLAGAS CREEK											
8A	144+00	173+94	C	1,300		6	300	5	CONCRETE BOX 15	72	4	0.003
	173+94	195+15	C	810		4.6	130	5	CONCRETE BOX 15	—	—	0.002
8b	195+15	227+35	C	510		5.3	—	4	16	—	—	0.0045
	WEST BRANCH LLAGAS CREEK											
9	0+00	55+00	C	5,200		6	867	9	90	130	6.7	0.0009
	55+00	169+00	C	4,200		6	700	8	80	114	6	0.0013
10	169+00	182+00	C	4,200		6	700	8	80	114	6	0.0013
	LIONS CREEK											
	182+00	195+00	C	2000		6	335	5	57			0.0012
	WEST BRANCH LLAGAS CREEK											
11a	182+00	220+00	C	2900		6	483	7	70	98	5	0.0013
11b	220+00	226+00	C	2,900		6	483	7	70	98	5	0.0023
	226+00	297+00	C	2,700		6	450	6	60	87	5	0.0023
	LIONS CREEK											
12	195+00	211+00	C	2,000		6	335	5	57			0.0012
	211+00	235+00	C	900		5.2	126	6	17			0.0025
	235+00	245+00	C	900				4	30			0.0035
	245+00	285+00	C	800		4.6	126	6	17			0.0025
	MOREY CHANNEL											
13	211+00	230+00	C	450		6		3	30			0.006
	230+00	245+00	C	465		6		3	30			0.006

DESIGNED BY: N. ZAGHI

LLAGAS CREEK - PHASE 1 - EXCAVATION ALTERNATE HYDRAULIC DESIGN SUMMARY

CHANNEL REACH NO.	STATION DESIGNATION		SOIL TYPE C=COHESIVE N.C.=NONCOHESIVE	Q DESIGN CAPACITY (CFS)	D75 (INCHES)	V (FT/SEC)	a (FT²)	d (FT)	b (FT)	p	r	s
	START	END										
13	217+00	233+00	C	465		6		3	30			0.006
	EAST LITTLE LLAGAS CREEK											
14	0+00	6+00	C	4,160		6	693	8	80	116	6	0.0018
	6+00	32+00	C	3,630		6	605	8	80	116	5	0.0022
	32+00	52+00	C	3,630		6	605	8	80	116	5	0.0022
	52+00	121+50	C	2,940		6	490	7	70	101	5	0.0024
	121+50	180+50	C	1,960		6	327	6	60	87	3.8	0.0034
	CORRALLITOS CREEK											
	0+00	6+45	C	1,440		6	240	5	50	72	3.3	0.004
15A	6+45	10+00	C	1,440		6		5	50			0.004
	10+00	45+20	C	1,440		6		5	50			0.004
15b	45+20	77+50	C	1,440		6		5	50			0.004
	TENNANT CREEK											
	77+50	126+70	C	640				5	50			0.004
	EAST LITTLE LLAGAS CREEK											
16	180+50	220+85	C	810		4.6		5	25			0.002

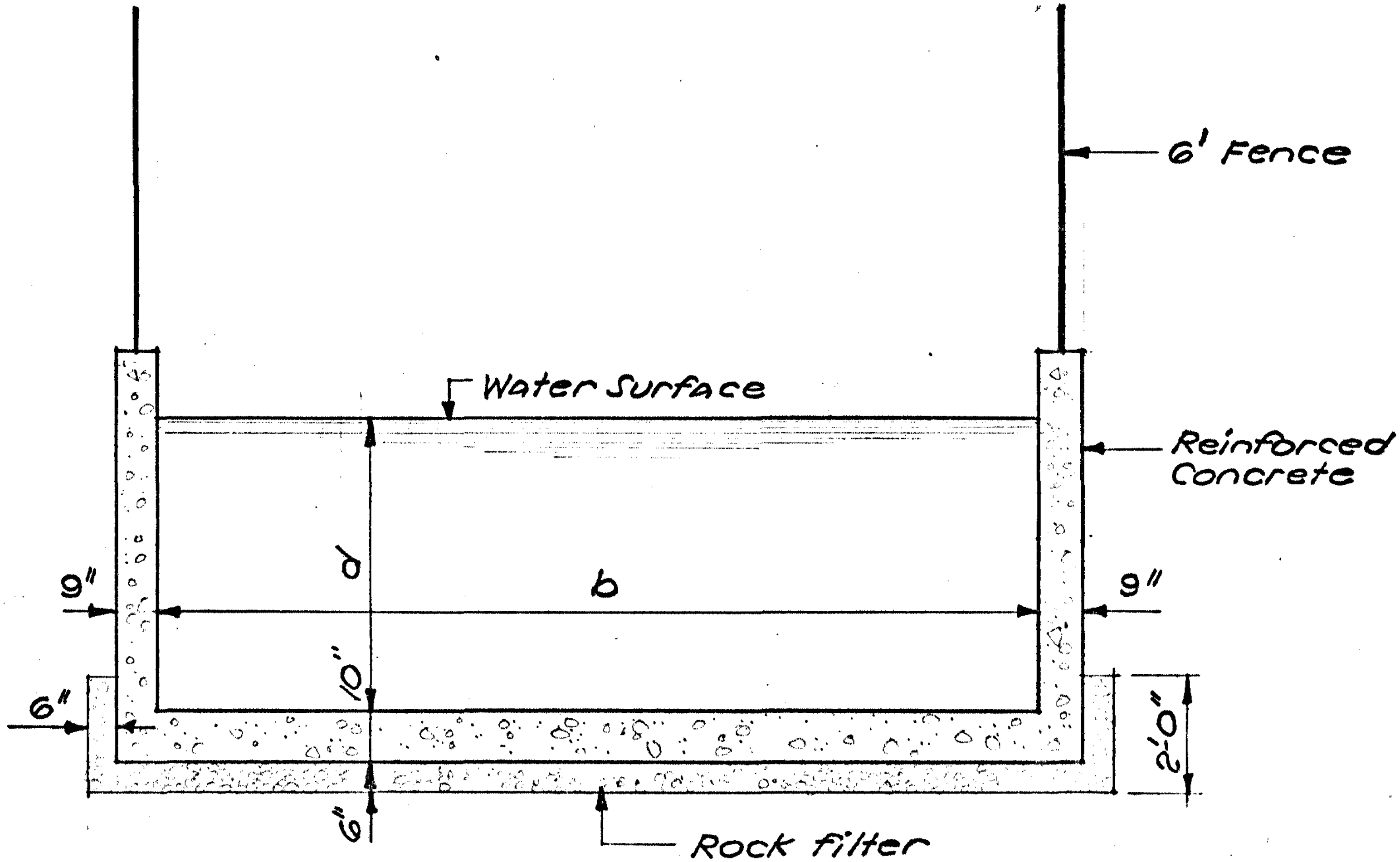
DESIGNED BY: N. ZAGHI
DMJM. JOB NO. 6209-1-1 SHEET 3 OF 3



TYPICAL SECTION

PHASE 1 - STRUCTURAL EXCAVATION ALTERNATE
(RIP RAP NOT SHOWN)

NO SCALE



TYPICAL SECTION
CONCRETE LINED CHANNELS

LLAGAS CREEK PHASE 1 LAND ACQUISITION

SUMMARY

A = SCCW&FCD B = STATE PURCHASE

Reach No.	Av. R/W Width (Feet)	R/W Needed for Phase 1 (Acres)	Prior Acquisition (Acres)	by	Balance of R/W Remaining for Purchase (Acres)
2	275	74.38	40.761	A	33.62
3	240	96.49	86.719	A	9.77
4	229	73.88	47.507	A	26.37
5	194	10.62	7.67	B	2.95
6a	194	112.10	.006	A	112.09
6b	166	11.93	---		11.93
7a	156	34.46	---		34.46
7b	138	10.71	---		10.71
7c	108	4.21	---		4.21
8a	25	2.94	---		2.94
8b	100	7.39	---		7.39
9	185	71.60	29.128 29.072	A B	13.40
10	163	9.70	.886	A	8.81
11a	166	14.48	7.770	A	6.71
11b	153	27.07	10.712	A	16.36
12	116	23.97	---		23.97
13	110	12.63	---		12.63
14	126	70.61	55.21	B	15.40
15a	138	12.28	---		12.28
15b	138	25.82	3.333	A	22.49
16	113	10.38	1.555		8.83
		717.65	320.329		397.32

LLAGAS CREEK

RECONNAISSANCE INVESTIGATION
(PHASE 2)
LEVEE ALTERNATE - 1% CHANCE

22 DECEMBER 1975

LLAGAS CREEK - RECONNAISSANCE INVESTIGATION

PHASE 2 LEVEE ALTERNATE 1% CHANCE

CONTENTS

PART I GENERAL DISCUSSION

PART II PROCEDURES AND ASSUMPTIONS

PART III SUMMARY OF ESTIMATED COSTS (including notes)

PART IV ENVIRONMENTAL MITIGATION AND LANDSCAPING MEASURES

PART V SUPPORTING INFORMATION

a) Plan of Reaches and Stationing System

b) Hydraulic Design Summary

c) Typical Sections

d) Right of Way Summary Table

PART I

GENERAL DISCUSSION

SCOPE

The investigation for the Levee Alternate is based on the same peak flows for a 1% chance design flood as furnished by the Soil Conservation Service for Phase 1. A brief hydraulic analysis was made on a reach by reach basis. The investigation includes the preparation of a comparative cost estimate in 1975 dollars and a review of environmental and landscaping mitigation measures.

CONCEPT

The levee alternate provides flood protection by constructing levees parallel to and set back from the existing creek banks. The levees will contain floodwaters overtopping the existing creek banks. The height of the levee generally varies from three to five feet. The existing creek bed and a strip of existing vegetation about thirty feet wide along each bank will be left undisturbed. Material to construct the levee will be obtained from shallow "borrow" excavation between the vegetation strip and the levee or from excavated channels in other parts of the watershed.

Velocities will not be controlled by structural modification of the creek and will be similar to maximum velocities presently occurring under existing conditions.

Diversions of flow as proposed in the 1966 Work Plan will be retained. Diversions will be according to the excavated channel solution proposed in Phase 1.

Reaches which were prior excavated by the State Highway are not suitable for the levee concept and therefore are considered as a Phase 1 solution.

REACH DESIGNATION AND STATIONING

The alignment of each reach closely follows the existing creek in most cases. As a result, the stationing system for the levee alternate is slightly different from the 1966 Work Plan. A key plan showing the designated reaches with adjusted stationing is included in Part V of this report. Reaches 3, 5, 9, and 14 are prior excavated and are not candidates for the levee solution. Reaches 7a, 12, and 13 are partly shown as cut channels to accomplish the required creek diversions.

TYPICAL SECTION

The proposed section is shown on the sketch included in Part V of this report. A maintenance access strip, 18 feet wide, is provided along the top of each levee. A shallow interceptor ditch outboard of the levees will collect stormwater from local runoff.

Exceptions to the typical section are prior excavated reaches and those in which proposed diversions occur. Such reaches will be constructed according to Phase 1 requirements and include all or portions of reaches 3, 5, 7a, 9, 10, 12, 13, and 14.

Reach 8a will be a rectangular lined concrete channel according to Phase 1 dimensions.

PART II

PROCEDURES AND ASSUMPTIONS

ALIGNMENT STATIONING

The stationing used for this study is modified from the system as developed for Phase 1 due to the difference in channel alignments. The modified stationing system is shown on the Plan in Part V.

SOILS

Limits of cohesive and noncohesive soils are as defined by the Government. Grain sizes for noncohesive soils are as shown in the original 1966 Work Plan.

CHANNEL DESIGN - GENERAL

1. Hydraulic criteria used in the design are as follows:
    a) Values of Q for the 1% design flood are as furnished by the Government.
    b) Maximum allowable velocities furnished by the Government are not applicable to the existing channel section. However, final

design of the reaches will consider non erosion velocities for flow against the new levee embankment and maximum velocities in the existing channel.

c) A value of "n" varying between 0.025 and 0.035 is used for the existing channel. An "n" of 0.050 is used for the overbank portion of the floodway.

d) Flow calculations are based on the Manning formula applied in accordance with SCS National Engineering Handbook Section 5.

CHANNEL LININGS

Riprap and filter stone will be provided in those reaches which are designated for the Channel Alternate (Phase 1) solution. Concrete lining will be provided for Reach 8a. Levees will be unlined because of the low estimated channel velocities in the overbank section.

GRADE STABILIZATION STRUCTURES

Grade stabilization structures are provided only on those sections designated for the Channel Alternate (Phase 1) solution.

DRAINAGE INLETS

The number of drainage structures as shown on the 1966 Work Plan appendix have been increased in proportion to the increased design flow.

BRIDGES AND CULVERTS

Bridges and culverts are assumed to be in the location shown in the 1966 Work Plan appendix. Bridges are assumed to span between in-board crests of levees. A cost allowance has been made for reconstruction of bridge approaches.

MISCELLANEOUS ITEMS

Miscellaneous items are as shown in the 1966 Work Plan appendix.

RIGHT OF WAY REQUIREMENTS

Right of way requirements are based on the required width to include the existing creek, the flood plain between the creek and the levee, the levees and access road and outboard collector ditches. A summary of right of way requirements is included in Part V.

BASIS FOR QUANTITY MEASUREMENT AND COST ESTIMATES

Quantities and cost estimates are similar to the Phase 1 report for corresponding items of work. The levees are estimated as compacted embankment measured by the cubic yard. The unit price includes the cost of excavation from the adjacent shallow borrow area or from reaches to be excavated under the Phase 1 solution.

FREEBOARD

A freeboard height of 2' - 0" is provided in the design of the levee system.

PART III

SUMMARY OF ESTIMATED COSTS

The general notes regarding the method of tabulation applicable to Phase 1 also apply to the Levee Alternate. Costs include reaches which are designated for the channel alternate and permits comparison between Phases 1 and 2 as a complete system.

Routine channel maintenance for levee reaches is estimated at $750 per mile per year. Channel reaches are estimated at $2,000 per mile per year.

LLAGAS CREEK -- SUMMARY OF ESTIMATED COSTS - PHASE 2, LEVEE ALTERNATE

REACH NO.	CAPITAL COSTS							AVERAGE ANNUAL COSTS			
	INSTALLATION COSTS (566 FUNDS)			OTHER INSTALLATION COSTS			GRAND TOTAL	CAPITAL COSTS AMORTIZED	M & O		TOTAL ANNUAL EQUIVALENT
	Construct	Eng.	Total	Land	Construct	Total			MI.	$	
2	1,135,800	284,000	1,419,800	527,100	422,200	949,300	2,369,100	80,300	2.24	1,700	82,000
4	701,600	175,400	877,000	1,849,400	720,400	2,569,800	3,446,800	116,800	2.35	1,700	118,500
6a	918,300	229,600	1,147,900	615,800	0	615,800	1,763,700	59,800	3.47	2,500	62,300
6b	138,200	34,500	172,700	47,900	0	47,900	220,600	7,500	0.70	500	8,000
7a	821,300	205,300	1,026,600	387,500	115,200	502,700	1,529,300	51,800	1.68	1,300	53,100
7b	241,300	60,300	301,600	165,400	306,200	471,600	773,200	26,200	0.66	500	26,700
7c	114,900	28,700	143,600	79,000	0	79,000	222,600	7,400	0.43	300	7,700
10	287,100	71,800	358,900	111,600	393,900	505,500	864,400	29,300	0.49	400	29,700
11a	223,100	55,800	278,900	381,800	311,900	693,700	972,600	33,000	0.76	600	33,600
11b	479,100	119,800	598,900	1,278,600	1,407,600	2,686,200	3,285,100	111,300	1.78	1,300	112,600
12	497,800	124,500	622,300	557,600	645,800	1,203,400	1,825,700	61,900	1.51	1,100	63,000
13	234,100	58,500	292,600	241,400	257,700	499,100	791,700	26,800	0.86	600	27,400
15a	212,800	53,200	266,000	185,900	24,800	210,700	476,700	16,200	0.69	500	16,700
15b	267,700	66,900	334,600	354,800	163,600	518,400	853,000	28,900	1.43	1,100	30,000
16	233,900	58,500	292,400	181,800	26,100	207,900	500,300	17,000	0.88	600	17,600
Subtotal	6,507,000	1,626,800	8,133,800	6,965,600	4,795,400	11,761,000	19,894,800	674,200	19.26	14,200	688,900
Other*	7,869,200	1,967,100	9,836,300	2,176,300	1,290,300	3,466,600	13,302,900	450,700	12.38	24,800	475,500
TOTAL	14,376,200	3,593,900	17,970,100	9,141,900	6,085,700	15,227,600	33,197,700	1,124,900	44.02	39,000	1,164,400

*Reaches 3, 5, 8a, 8b, 9 and 14 which are excavation alternates. See Phase 1 for cost detail.

PART IV

ENVIRONMENTAL MITIGATION AND LANDSCAPING MEASURES

The potentially adverse environmental impacts associated with the levee alternate (Phase 2) have been identified as shown in the Impact Matrix that follows. Potential means for mitigating some of the important adverse impacts associated with this alternate are outlined below.

ECOLOGY

- Removal of flood plain vegetation in the process of levee construction can be mitigated by a program for replanting and landscaping of disturbed areas adjacent to the levees.

AIR QUALITY

- Short term decrease in air quality due to construction dust generation and vehicle emissions can be mitigated to a certain extent by limiting the transportation of materials and/or equipment to designated roads or areas. Dust can be minimized by clean up, sprinkling, or other acceptable practices.

HISTORICAL AND ARCHEOLOGICAL RESOURCES

Every effort will be made to preserve the Virgil Moniz house and its grounds in Morgan Hill. If the house cannot be saved, a detailed architectural and archeological study of the premises should be conducted prior to construction.

Prior to construction, sample excavations should be undertaken at the three possible prehistoric sites in the section of Llagas Creek south of San Martin to Buena Vista Avenue. Based on this determination, salvage excavations will be provided for if necessary. Archeological salvage will be done in consultation with the National Park Service.

LANDSCAPE CONCEPT

The natural creek channel has developed over years of interaction between water, soil, plant and weathering process. Generally the creek is uneven and natural, having a variety of tree groves and plant masses. There is an inherent sense of visual continuity to the natural creek.

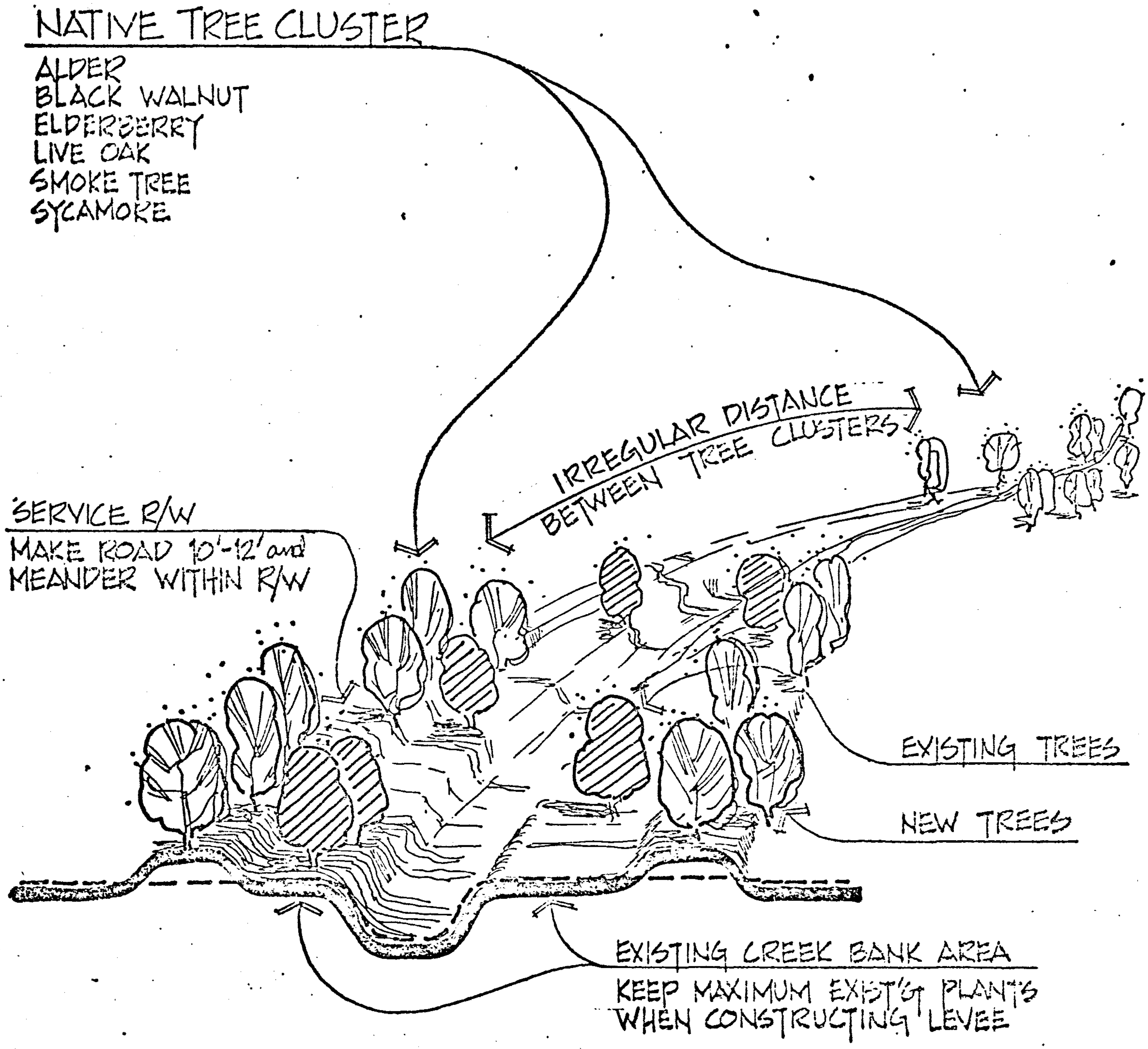
The proposed levee construction will create some change to the levee site and adjacent borrow strip and surrounding environment. In order to provide appropriate environmental mitigation and landscaping measures, general landscape concepts have been developed.

1. Retain as many major trees and plant masses as possible. The large tree groves and plant masses are key elements of both the intimate and distant visual landscape.

2. Plant large clusters of trees at all public road crossings and along the creek where it parallels public roads. The tree and plant masses will screen the newly constructed levees and ultimately create a pleasant, natural and spacial experience in the public areas.

3. Plant tree clusters at random distances along the new levees. The tree groves will visually tie the creek into the surrounding landscape, creating a natural environment.

4. Allow native wildflowers, grasses and shrubs to be re-established along the new levee construction.


NATIVE TREE CLUSTER
ALDER
BLACK WALNUT
ELDERBERRY
LIVE OAK
SMOKE TREE
SYCAMORE
IRREGULAR DISTANCE BETWEEN TREE CLUSTERS
SERVICE R/W
MAKE ROAD 10'-12' and MEANDER WITHIN R/W
EXISTING TREES
NEW TREES
EXISTING CREEK BANK AREA
KEEP MAXIMUM EXIST'G PLANTS WHEN CONSTRUCTING LEVEE

LANDSCAPE CONCEPT
LEVEE CHANNEL
LLAGAS CREEK

PART V

SUPPORTING INFORMATION

LEGEND

▨ CUT CHANNEL

▭ EXISTING NATURAL CREEK

LLAGAS CREEK

KEY PLAN

PHASE # 2 - LEVEE EMBANKMENT

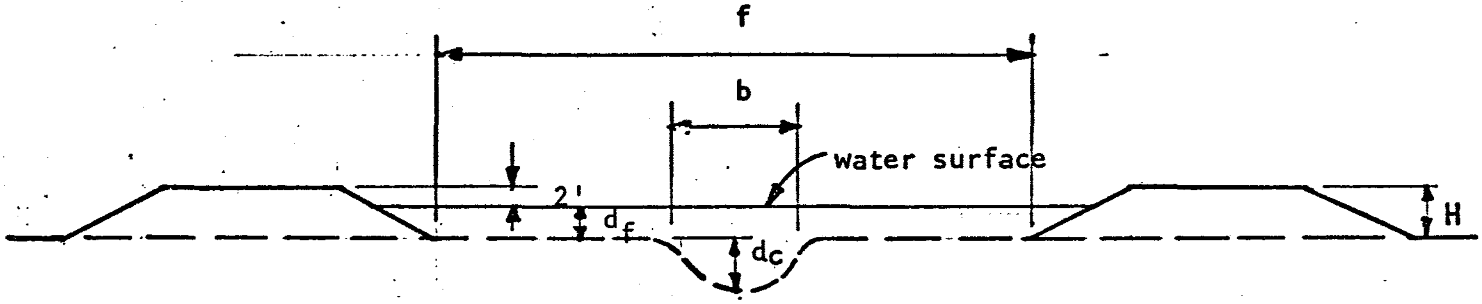
REACHES & STATIONING SYSTEM

GRAPHIC SCALE

2000 0 2000 4000

HYDRAULIC DESIGN SUMMARY - PHASE 2

EXPLANATION OF SYMBOLS



S = Average slope of ground surface and channel in feet per foot
Q = Design Storm Flow in cubic feet per second
n = Mannings friction coefficient
b = Effective width of existing channel in feet
d_c = Effective water depth of existing channel in feet
d_f = Water depth of floodway in feet
A_c = Effective cross sectional area of existing channel in feet
A_f = Cross sectional area of floodway in feet
f = Width of floodway in feet
r = Hydraulic radius
V_c = Average velocity in existing channel in feet per second
V_f = Average velocity in floodway in feet per second
Q_c = Estimated flow in existing channel in cubic feet per second
Q_f = Estimated flow in floodway in cubic feet per second
H = Nominal height of levee

LLAGAS CREEK PHASE 2 - LEVEE ALTERNATE

HYDRAULIC DESIGN SUMMARY

REACH NO.	STATION DESIGNATION		EXIST. GD. ELEV.		S	Q	EXISTING CHANNEL							FLOODWAY							H	
	START	END	START	END			n	b	d_c	A_c	r	V_c	Q_c	n	f	d_f	A_f		V_f	Q_f		
	LOWER LLAGAS CREEK																					
2	64+00	93+40	142.0	148.0	0.0020	13,900	0.035	36	13	806	8.56	7.94	6,400	0.05	650	3	1968		3.8	7,500	5	
	93+40	127+40	148.0	163.5	0.0046	17,100	0.035	30	16	992	9.76	13.01	12,900	0.05	450	3	1368		3.0	4,200	5	
	127+40	150+00	163.5	172.2	0.0038	16,300	0.035	25	16	912	9.44	11.78	10,743	0.05	480	3	1458		3.8	5,557	5	
	150+00	176+00	172.2	180.8	0.0033	16,300	0.035	30	18	1188	10.75	11.97	14,220	0.05	350	3	1068		1.9	2,080	5	
	176+00	182+00	180.8	182.8	0.0033	16,300	0.035	30	18	1188	10.75	11.97	14,220	USE PHASE 1 SOLUTION								
4	379+00	386+00	219.9	222.0	0.0030	9,300	0.035	50	7	448	5.51	7.2	3,229	0.05	600	3	1818		3.3	6,070	5	
	386+00	396+00	222.0	225.0	0.0030	8,900	0.035	60	7	518	5.56	7.34	3,802	0.05	560	3	1698		3.0	5,098	5	
	396+00	408+00	225.0	228.0	0.0025	8,900	0.035	50	7	448	5.51	6.66	2,983	0.05	620	3	1878		3.1	5,917	5	
	408+00	420+00	228.0	230.0	0.0017	8,900	0.035	45	7	413	5.41	5.42	2,238	0.05	650	3	1968		3.3	6,662	5	
	420+00	441+00	230.0	233.5	0.0017	8,900	0.035	90	7	728	6.00	5.81	4,229	0.05	600	3	1818		2.5	4,671	5	
	441+00	460+00	233.5	236.5	0.0016	8,900	0.035	60	7	518	5.67	5.43	2,937	0.05	640	3	1938		3.0	5,963	5	
	UPPER LLAGAS CREEK																					
	460+00	471+00	236.5	240.0	0.0032	8,900	0.035	70	7	588	5.80	7.79	4,580	0.05	410	3	1248		3.4	4,320	5	
	471+00	476+00	240.0	241.0	0.0020	8,900	0.035	60	7	518	5.67	6.07	3,144	0.05	620	3	1878		3.0	5,756	5	
	476+00	503+50	241.0	248.5	0.0027	8,900	0.035	80	7	658	5.91	7.25	4,770	0.05	420	3	1278		3.2	4,130	5	
6a	522+00	580+00	253.0	267.0	0.0024	5,400	0.030	60	7	518	5.67	7.76	4,019	0.05	200	3	618		1.4	901	5	
	580+00	605+00	267.0	276.0	0.0036	5,100	0.030	60	7	518	5.67	9.50	4,921	0.05	20	3	78		2.2	179	5	
	605+00	650+00	276.0	290.0	0.0031	5,100	0.030	100	7	798	6.07	9.23	7,365	0.05	100	0	—		—	—	—	
	650+00	675+00	290.0	298.0	0.0032	5,100	0.030	60	7	518	5.67	9.38	4,858	0.05	120	2	244		1	242	4	
	675+00	687+00	298.0	302.0	0.0033	5,100	0.030	60	7	518	5.67	9.38	4,858	0.05	120	2	244		1	242	4	
	687+00	705+82	302.0	308.5	0.0035	5,100	0.030	70	7	538	5.80	9.50	5.586	0.05	70	0	—		—	—	—	
6b	705+82	743+00	308.5	321.0	0.0034	3,430	0.035	80	7	658	5.91	8.14	5,356	0.05	80	0	—		—	—	—	
	WEST LITTLE LLAGAS CREEK																					
7a	0+00	34+00	305	320.0	0.0044	2,160	—			—	—		—	USE PHASE 1 SOLUTION								
	34+00	64+00	320.0	321.5	0.0005	2,160	—			—	—		—	USE PHASE 1 SOLUTION								
	64+00	89+00	321.5	324.5	0.0012	1,680	—			—	—		—	USE PHASE 1 SOLUTION								
7b	89+00	98+50	324.5	327.0	0.0026	1,470	—			—	—		—	0.05	150	3	468		3.1	1,470	5	
	98+50	118+70	327.0	335.0	0.0040	1,470	0.045	5	5	25	1.67	2.94	73	0.05	120	3	378		3.8	1,470	5	
	118+70	123+80	335.0	338.0	0.0059	1300	0.045	5	5	25	1.67	2.94	73	0.05	85	3	273		4.7	1300	5	
	EDMUNDSON CREEK																					
7c	0+00	23+00	321.5	324.5	0.0013	465	0.045	5	1	5	1.40	1.50	7	0.05	67	3	219		2.0	458	5	

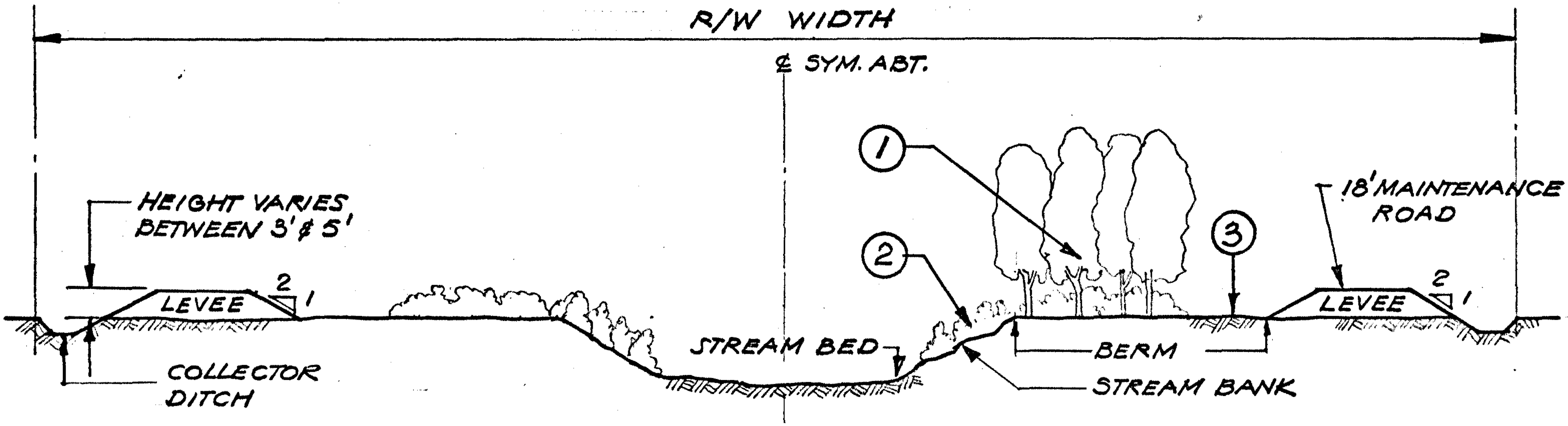
REVISED DEC. 22, 1975

LLAGAS CREEK PHASE 2 - LEVEE ALTERNATE

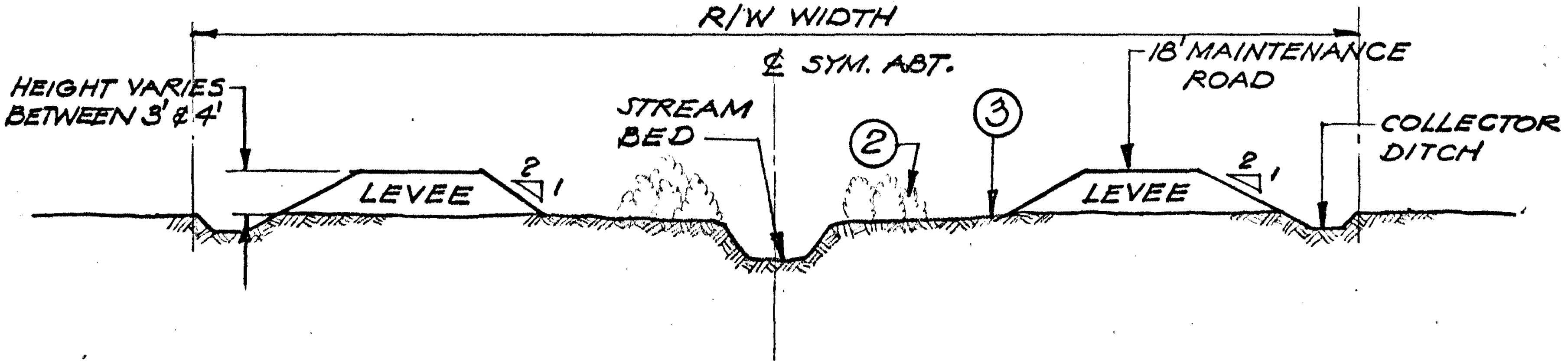
HYDRAULIC DESIGN SUMMARY

REACH NO.	STATION DESIGNATION		EXIST. GD. ELEV.		S	Q	EXISTING CHANNEL							FLOODWAY							H	
	START	END	START	END			n	b	d_c	A_c	r	V_c	Q_c	n	f	d_f	A_f		V_f	Q_f		
	WEST BRANCH LLAGAS CREEK																					
10	169+00	179+50	208.0	209.0	0.0010	4,200	—	—	—	—	—	—	—	USE PHASE 1 SOLUTION								
	LIONS CREEK																					
	179+50	195+00	209.0	210.5	0.0010	2,000	—	—	—	—	—	—	—	USE PHASE 1 SOLUTION								
	WEST BRANCH LLAGAS CREEK																					
11a	179+50	220+00	209.0	219.9	0.0027	2,900	0.05	4	3	12	1.2	0.5	6	0.05	250	3	762		3.8	2,894	5	
11b	220+00	226+00	219.9	220.0	0.0002	2,900	0.045	—	—	—	—	—		0.05	650	3	1968		1.4	2,900	5	
	226+00	314+00	220.0	244.5	0.0028	2,700	0.045	10	3	30	0.54	0.5	15	0.05	560	3	1680		1.6	2,685	5	
	LIONS CREEK																					
12	195+00	199+50	210.5	211.5	0.0022	2,000	—	—	—	—	—	—		USE PHASE 1 SOLUTION								
	199+50	211+00	211.5	214.5	0.0026	2,000	0.045	2	2	4	0.67	1.3	5	0.05	400	3	1218		1.6	1995	5	
	211+00	240+00	214.5	220.5	0.0021	900	0.045	2	2	4	0.67	1.3	5	0.05	120	3	378		2.4	895	5	
	240+00	250+00	220.5	225.0	0.0045	900	0.045	2	2	4	0.67	1.3	5	0.05	120	3	378		2.4	895	5	
	250+00	275+00	225.0	239.5	0.0058	800	0.045	2	2	4	0.67	1.3	5	0.05	180	3	540		1.4	795	5	
	MOREY CHANNEL																					
13	199+50	217+00	211.5	213.8	0.0013	450	—	—	—	—	—	—		USE PHASE 1 SOLUTION								
	217+00	228+50	213.8	215.3	0.0013	450	—	—	—	—	—	—		USE PHASE 1 SOLUTION								
	228+50	245+00	215.3	219.3	0.0024	465	—	—	—	—	—	—		0.05	50	3	168		2.7	465	5	
	NORTH MOREY CHANNEL																					
	217+00	233+00	213.8	217.3	0.0022	465	0.045	8	3	24	0.59	1.1	26	0.05	50	3	168		2.6	439	5	
	CORALLITOS CREEK																					
15a	6+50	10+00	289.0	290.0	0.0029	1,440	0.040	10	4	40	2.23	3.4	136	0.05	120	3	378		3.4	1304	5	
	10+00	18+00	290.0	294.5	0.0056	1,440	0.040	10	4	40	2.23	3.4	136	0.05	86	3	276		4.7	1304	5	
	18+00	43+15	294.5	304.0	0.0038	1,440	0.045	2	2	4	0.67	1.3	14	0.05	120	3	378		3.7	1426	5	
15b	43+15	78+50	304.0	316.0	0.0034	1,440	0.045	10	5	50	2.50	3.5	175	0.05	120	3	378		3.3	1265	5	
	TENNANT CREEK																					
	78+50	86+00	316.0	318.0	0.0027	640	0.035	5	4	20	1.53	3	60	0.05	100	3	318		1.8	580	5	
	86+00	90+00	318.0	319.5	0.0038	640	0.035	5	1	5	0.71	2	10	0.05	55	3	183		3.4	630	5	
	90+00	105+00	319.5	324.5	0.0033	640	0.035	5	1	5	0.71	2	10	0.05	55	3	183		3.4	630	5	
	105+00	118+80	324.5	329.0	0.0033	640	0.035	5	1	5	0.71	2	10	0.05	55	3	183		3.4	630	5	
	EAST LITTLE LLAGAS CREEK																					
16	180+50	227+00	301.0	311.0	0.0022	810	0.040	10	4	40	2.23	3	120	0.05	70	3	228		3.0	690	5	

REVISED DEC. 22, 1975 SHEET 2 OF 2

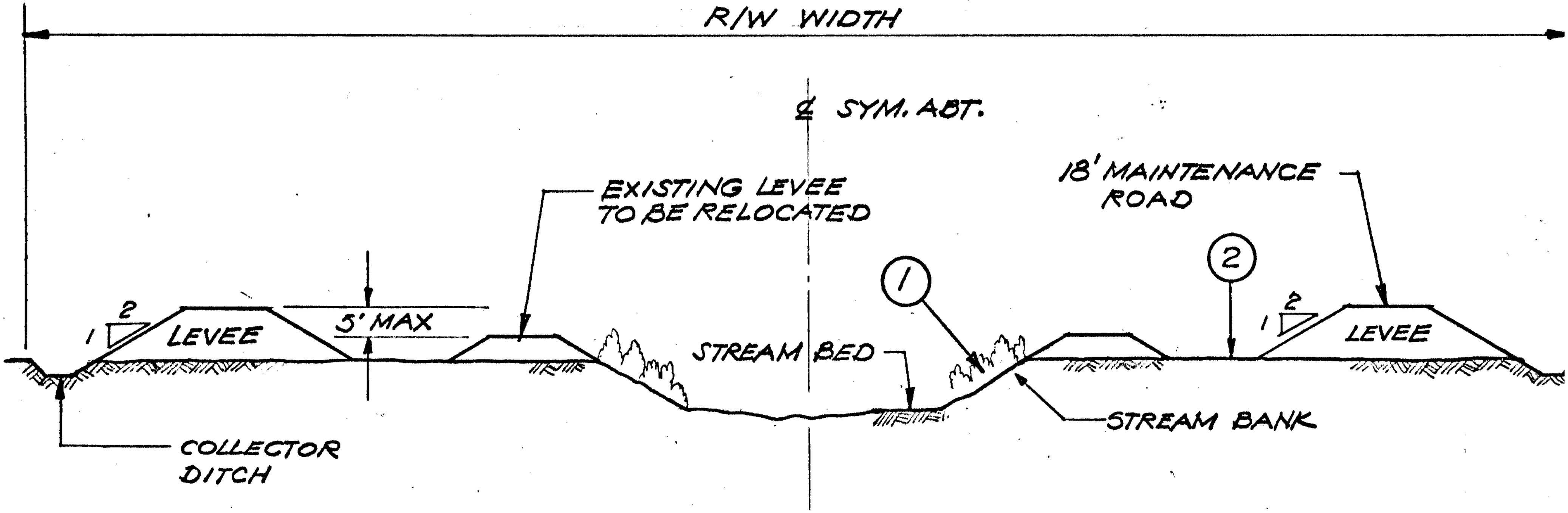


TYPICAL SECTION FOR WELL DEFINED NATURAL CHANNELS



TYPICAL SECTION FOR SMALL UPSTREAM CHANNELS

1. EXISTING TREES TO REMAIN OR TO BE REPLANTED AS RECOMMENDED IF REMOVAL IS NECESSARY.
2. EXISTING VEGETATION TO REMAIN OR TO BE REPLANTED AS RECOMMENDED AND MAINTAINED BY MECHANICAL METHODS.
3. NATURAL GROUND LINE.



SPECIAL CONDITION

TYPICAL SECTION FOR REACH NOS. 2 & 4 ONLY

1. EXISTING VEGETATION TO REMAIN OR TO BE REPLANTED AS RECOMMENDED AND MAINTAINED BY MECHANICAL METHODS.
2. NATURAL GROUND LINE.

RIGHT OF WAY SUMMARY TABLE

Reach No.	Av. R/W Width (Feet)	R/W Needed Phase 2 (Acres)	Prior Acquisition (Acres)	Balance of R/W to be Purchased (Acres)
2	544	153.430	40.761	112.669
3*	240	96.490	86.719	9.771
4	657	183.460	47.507	135.953
5*	194	10.620	7.670	2.950
6a	184	83.660	0.006	83.654
6b	128	10.930	---	10.930
7a	338	69.170	---	69.170
7b	206	16.870	---	16.870
7c	155	8.180	---	8.180
8a*	25	2.940	---	2.940
8b*	100	7.390	---	7.390
9*	185	71.600	58.200	13.400
10	598	34.430	0.886	33.544
11a	338	31.430	7.770	23.660
11b	693	141.080	10.712	130.368
12	332	52.250	---	52.250
13	243	35.930	---	35.930
14*	126	70.610	55.210	15.400
15a	196	16.820	---	16.820
15b	165	30.880	3.333	27.547
16	158	16.870	1.555	15.315
		1145.040	320.329	824.711

*R/W requirements same as Phase 1.

LLAGAS CREEK

RECONNAISSANCE INVESTIGATION
(PHASE 3)
CLEARING ALTERNATE

22 DECEMBER 1975

LLAGAS CREEK - RECONNAISSANCE INVESTIGATION

PHASE 3 CLEARING ALTERNATE

CONTENTS

PART I GENERAL DISCUSSION

PART II PROCEDURES AND ASSUMPTIONS

PART III ENVIRONMENTAL MITIGATION AND LANDSCAPING MEASURES

PART I

GENERAL DISCUSSION

SCOPE

Certain creeks have been selected by the Soil Conservation Service for investigation of a clearing solution which would possibly provide increased flow by clearing brush and vegetation in the creek bed. The investigation is limited to some of the upper reaches of the Llagas Creek system and is not related to any specific design flow but simply a potential increase in flow within the creek by clearing methods.

CONCEPT

Most of the upper creek channels are relatively narrow and have become choked with vegetation, debris and brush growth which has encroached within the waterway area.

Generally there has been no effort to clear the channels and presumably the situation will become progressively worse as the vegetation consolidates. One landowner apparently performs annual maintenance on a portion of a reach passing through his lands. The creek bottom had been cleared and grubbed by discing or hoeing and the bank vegetation trimmed or removed. Any obstructions or debris had been removed. Such a clearing concept is the one one which the investigation is based. Some of the larger creeks were relatively clear and it is doubtful if clearing will have a significant effect.

REACH DESIGNATION AND STATIONING

Reaches and stationing are selected from those designated for the Levee Alternate (Phase 2). The particular reaches studied are 6a, 6b, 7a, 7b, 7c, 11a, 11b, 12, 13, 15a, 15b, and 16.

TYPICAL SECTION

Because of varying conditions encountered it is inappropriate to consider a typical section. However, most of the reaches investigated had a bottom width of about ten feet and a bank height of between five and ten feet.

FINDINGS

The capacities of existing channels before and after clearing are shown in the following table. In general, the increase in capacity does not meet the design flows for the 1% chance or 10% chance flood. In those portions of reach 6a and 6b which already have an existing capacity near or greater than the design flows, clearing only does not appear to produce any improvement.

For the smaller reaches, clearing produces some measurable improvement over existing capacities, but still falls far short of providing significant flood protection.

Clearing appears ineffective as a meaningful solution to a serious flood problem, but in some cases may provide partial mitigation of flooding due to less severe rainstorms than are considered in this report.

The estimated cost of clearing was based on an average unit price of $0.50 per linear foot of creek.

PART II

PROCEDURES AND ASSUMPTIONS

EXISTING CREEK CAPACITIES

Where available, existing creek capacities were taken from the 1966 Work Plan report. Otherwise, creek capacities were roughly evaluated from field observations. It was noted that capacities sometimes varied widely within any one reach. The capacities shown are an estimated average only.

SELECTION OF "n" VALUE

Assigning a roughness coefficient "n" to the before and after clearing condition was judgmental. It was not derived from prior field measurements or tests. Before and after flows were estimated relative to the change in "n" value. The results are sufficiently accurate to make general observations regarding any benefits of clearing.

RIGHT OF WAY REQUIREMENTS

It is assumed that clearing would be done on an informal basis with prior permission of the adjacent landowners. If necessary, a no-cost maintenance easement might be obtained. Specific right of way purchase is not considered necessary.

LLAGAS CREEK PHASE 3

CAPACITIES OF EXISTING CHANNELS BEFORE AND AFTER CLEARING

Channel Reach No.	Channel Designation		Design Discharge 1% Chance c.f.s.	Existing Capacity c.f.s.	Capacity with Clearing c.f.s.	Length to be Cleared l.f.	Cost of Clearing $
	Begin Sta.	End Sta.					
6a	522+00	605+00	5,400	3,000*	3,000	no benefit	--
	605+00	650+00	5,100	6,500*	6,500	"	
	650+00	703+70	5,100	3,500*	3,500	"	--
6b	703+70	743+00	3,430	3,000to 5,000	3,400to 5,800	3,930	2,000
7a	0+00	75+00	new channel				
	75+00	89+00	1,680	100*	134	1,400	700
7b	96+40	144+00	1,470	100*	150	4,760	2,400
7c	0+00	17+00	465	35*	35	1,700	900
11a	179+50	220+00	2,900	28**	40	4,050	2,000
11b	220+00	314+00	2,700	28**	40	9,400	4,700
12	195+00	287+50	2,000	28**	40	9,250	4,600
13	199+50	233+00	465	56**	84	3,350	1,700
15a	6+50	42+00	1,440	421*	562	3,550	1,800
15b	42+00	78+50	1,440	97*	130	3,650	1,800
	78+50	126+00	1,440	470*	470	4,750	2,400
16	180+50	220+85	810	40*	54	4,035	2,000

* Existing capacity from 1966 Work Plan
** Estimated by DMJM

PART III

ENVIRONMENTAL MITIGATION AND LANDSCAPING MEASURES

The potentially adverse environmental impacts resulting from the clearing alternate (Phase 3) are identified in the Impact Matrix in the previous summary report.

The nature of the clearing alternate is such that there are no applicable measures to reduce or eliminate the adverse impacts of channel clearing and landscaping is not appropriate.

LLAGAS CREEK

RECONNAISSANCE INVESTIGATION

PHASE 4A CHANNEL ALTERNATE - 10% CHANCE
PHASE 4B LEVEE ALTERNATE - 10% CHANCE

22 DECEMBER 1975

LLAGAS CREEK - RECONNAISSANCE INVESTIGATION

PHASE 4A CHANNEL ALTERNATE 10% CHANCE

PHASE 4B LEVEE ALTERNATE 10% CHANCE

CONTENTS

PART I GENERAL DISCUSSION

PART II PROCEDURES AND ASSUMPTIONS

PART III SUMMARY OF ESTIMATED COSTS

PART IV ENVIRONMENTAL MITIGATION AND LANDSCAPING MEASURES

PART V SUPPORTING INFORMATION

- a) Hydraulic Design Summaries
- b) Right of Way Summary Table

PART I

GENERAL DISCUSSION

SCOPE

The investigation for the 1% chance flood, or protection from a storm with a predicted frequency of occurrence of one in every 100 years, is described in Phases 1 and 2, the Channel Alternate and Levee Alternate respectively.

Phase 4 investigates the 10% chance or a design storm of 10 year frequency. The Channel Alternate is Phase 4A and the Levee Alternate is Phase 4B. Certain upper reaches of the Llagas Creek system are designated by the Soils Conservation Service as being appropriate for study. The investigation includes the preparation of a comparative cost estimate in 1975 dollars and a discussion of environmental mitigation and landscaping measures.

CONCEPT

The concepts for Alternates 4A and 4B are essentially similar to the concepts applicable to Phases 1 and 2 respectively. Only the design storm has been reduced in intensity.

REACH DESIGNATION AND STATIONING

Reaches selected by SCS for Phases 4A and 4B are numbers 11a, 11b, 12, 13, 15a, 15b, and 16. The stationing system for Phase 1 and 2 respectively is applicable.

TYPICAL SECTIONS

Reaches for channel sections are similar to Phase 1 solution. Reaches for levee section are similar to the Phase 2 solution except that the levee height varies from two to four feet.

QUANTITY AND COST VARIATIONS FROM PHASE 1 AND 2 SOLUTIONS

Phase 4A quantities and costs show savings primarily in excavation and right of way requirements over the Phase 1 solution. The cost of improving the reaches for a 10% chance flood is 4.8 million; the cost of improving the same reaches for a 1% chance flood is 5.9 million.

Phase 4B quantities and costs show savings primarily in levee embankment and right of way requirements over the Phase 2 solution. The cost of levees for a 10% chance flood is 6.9 million; the cost of levees for the same reaches for a 1% chance flood is 8.7 million.

PART II

PROCEDURES AND ASSUMPTIONS

Procedures and assumptions are identical with those applicable in the corresponding Phase 1 and Phase 2 investigations except:

a) Values of Q furnished by the Government are for the 10% chance flood.

PART III

SUMMARY OF ESTIMATED COSTS

Separate cost estimates have been tabulated for Phases 4A and 4B. The same method of presentation is used as for Phases 1 and 2.

Totals shown include only the reaches investigated for the 10% chance. The cost of the remaining reaches will be as shown in cost tabulations for either Phase 1 or Phase 2.

For comparison purposes the cost of the equivalent reaches for Phase 1 and 2 is shown at the foot of the respective tables.

PART III LLAGAS CREEK - SUMMARY OF ESTIMATED COSTS - PHASE 4A, EXCAVATION ALTERNATE

REACH NO.	CAPITAL COSTS							AVERAGE ANNUAL COSTS			
	INSTALLATION COSTS (566 FUNDS)			OTHER INSTALLATION COSTS			GRAND TOTAL	CAPITAL COSTS AMORTIZED	M & O		TOTAL ANNUAL EQUIVALENT
	Construct	Eng.	Total	Land	Construct	Total			MI.	$	
11a	352,100	88,000	440,100	152,200	114,900	267,100	707,200	24,000	0.767	600	24,600
11b	576,300	144,100	720,400	201,800	53,300	255,100	975,500	33,000	1.780	1,300	34,300
12	583,400	145,900	729,300	217,200	51,600	268,800	998,100	33,900	1.515	1,100	35,000
13	341,600	85,400	427,000	111,100	23,000	134,100	561,100	19,000	.862	700	19,700
15a	278,900	69,700	348,600	101,900	25,500	127,400	476,000	16,100	.694	500	16,600
15b	319,000	79,700	398,700	199,900	152,200	352,100	750,800	25,400	.763	600	26,000
16	161,300	40,300	201,600	86,700	16,500	103,200	304,800	10,300	.863	600	10,900
TOTAL	2,612,600	653,100	3,265,700	1,070,800	437,000	1,507,800	4,773,500	161,700	7.244	5,400	167,100
SAME REACHES PHASE 1 TOTAL	3,170,500	692,800	3,963,300	1,341,300	625,400	1,966,700	5,930,000	200,900	7.840	15,600	2,165,500

LLAGAS CREEK - SUMMARY OF ESTIMATED COSTS - PHASE 4B, LEVEE ALTERNATE

REACH NO.	CAPITAL COSTS							AVERAGE ANNUAL COSTS			
	INSTALLATION COSTS (566 FUNDS)			OTHER INSTALLATION COSTS			GRAND TOTAL	CAPITAL COSTS AMORTIZED	M & O		TOTAL ANNUAL EQUIVALENT
	Construct	Eng.	Total	Land	Construct	Total			MI.	$	
11a	220,500	55,100	275,600	242,700	168,400	411,100	686,700	23,300	0.76	600	23,900
11b	463,000	115,800	578,800	850,100	844,600	1,694,700	2,273,500	77,000	1.78	1,300	78,300
12	480,200	120,100	600,300	509,400	436,100	945,500	1,545,800	52,400	1.51	1,100	53,500
13	215,000	53,800	268,800	166,900	210,900	377,800	646,600	21,900	0.86	600	22,500
15a	210,400	52,600	263,000	297,100	18,800	315,900	578,900	19,600	0.69	500	20,100
15b	276,600	69,200	345,800	235,200	140,500	375,700	721,500	24,400	1.43	1,100	25,500
16	230,200	57,500	287,700	169,500	18,800	188,300	476,000	16,100	0.88	600	16,700
TOTAL	2,095,900	524,100	2,620,000	2,470,900	1,838,100	4,309,000	6,929,000	234,700	7.24	5,800	240,500
SAME REACHES PHASE 2 TOTAL	2,148,500	537,200	2,685,700	3,181,900	2,837,500	6,019,400	8,705,100	295,100	7.24	5,800	300,900

PART IV

ENVIRONMENTAL MITIGATION AND LANDSCAPING MEASURES

The potentially adverse impacts of the Phase 4 alternates are considered to be essentially the same as those identified for Phases 1 and 2 (refer to Impact Matrix).

While the extent or "degree" of potential impacts may be lessened by the 10% criteria, it is expected that the mitigating measures outlined for Phases 1 and 2 will still apply.

LANDSCAPE CONCEPT

The landscape concept for Phases 4A and 4B will be similar to Phases 1 and 2 respectively.

LANDSCAPING COSTS

The following tables list landscaping costs for Phase 4A and 4B. The format and incidental costs are similar to the estimates prepared for Phases 1 and 2.

Landscaping costs are in addition to channel construction costs shown in Part III of this report.

PART V

SUPPORTING INFORMATION

HYDRAULIC DESIGN SUMMARY TABLE - PHASE 4A

EXPLANATION OF SYMBOLS

C = Cohesive soil

NC = Noncohesive soil

Q = Design storm flow in cubic feet per second

D75 = Soil grain size 75% percentile

V = Average water velocity in feet per second

A = Effective channel cross sectional area in square feet

d = Depth of water in feet

b = Width of channel bottom in feet

p = Wetted perimeter of channel in feet

r = Hydraulic radius of channel

s = Slope of channel in feet per foot

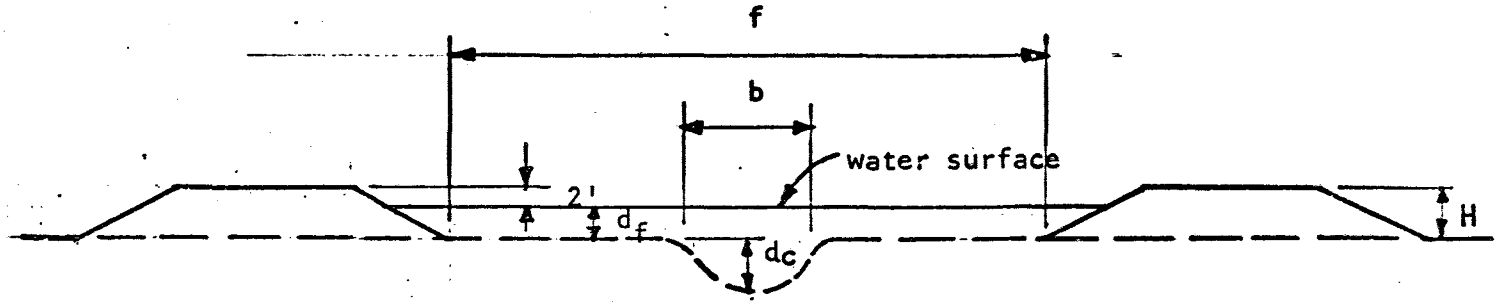
LLAGAS CREEK - PHASE 4a - EXCAVATION ALTERNATE (10% CHANCE) HYDRAULIC DESIGN SUMMARY

CHANNEL REACH NO.	STATION DESIGNATION		SOIL TYPE	Q DESIGN CAPACITY C.F.S.	V FT/SEC	a	d	b	p	r	s	
	START	END										
	WEST BRANCH LLAGAS CREEK											
11a	182+00	220+00	C *	1450	6	241.7	5	50	72.35	3.34	0.002	
11b	220+00	226+00	C	1,350	6	225	5	50	72.35	3.34	0.002	
	226+00	297+00	C	1,350	6	225	5	50	72.35	3.34	0.002	
	LIONS CREEK											
12	195+00	211+00	C	450	3	75	≃ 2.5	25	36.17	2.07	0.0009	
	211+00	235+00	C	450	6	75	≃ 2.5	25	36.17	2.07	0.0036	
	235+00	245+00	C	400	6							
	245+00	285+00	C	400	6	66.7	≃ 2.5	25	36.17	2.07	0.0036	
	MOREY CHANNEL											
13	211+00	230+00	C	225	5	37.5	≃ 1.8	20	28.01	1.4	0.0045	
	230+00	245+00	C	100	5	16.7	≃ 1.8	20	28.01	1.4	0.0045	
	NORTH MOREY CHANNEL											
	217+00	233+00	C	140	6	23.4	1.5	15	25.5	1.07	0.009	
	CORALLITOS CREEK											
15a	6+45	10+00	C	700	6	116.7	≃ 3	30	43.41	2.6	0.0027	
	10+00	45+20	C	700	6	116.7	≃ 3	30	43.41	2.6	0.0027	
15b	45+20	77+50	C	700	6	116.7	≃ 3	30	43.41	2.6	0.0027	
	TENNANT CREEK											
	77+50	126+70	C	320	6	53.4	≃ 2	20	29.5	1.8	0.004	
	EAST LITTLE LLAGAS CREEK											
16	180+50	220+50	C	330	4.8	55	≃ 2.1	20	29.5	1.8	0.003	

*C = COHESIVE

HYDRAULIC DESIGN SUMMARY - PHASE 4B

EXPLANATION OF SYMBOLS



S = Average slope of ground surface and channel in feet per foot
Q = Design Storm Flow in cubic feet per second
n = Mannings friction coefficient
b = Effective width of existing channel in feet
d_c = Effective water depth of existing channel in feet
d_f = Water depth of floodway in feet
A_c = Effective cross sectional area of existing channel in feet
A_f = Cross sectional area of floodway in feet
f = Width of floodway in feet
r = Hydraulic radius
V_c = Average velocity in existing channel in feet per second
V_f = Average velocity in floodway in feet per second
Q_c = Estimated flow in existing channel in cubic feet per second
Q_f = Estimated flow in floodway in cubic feet per second
H = Nominal height of levee

LLAGAS CREEK PHASE 4b - LEVEE ALTERNATE

HYDRAULIC DESIGN SUMMARY

REACH NO.	STATION DESIGNATION		EXIST. GD. ELEV.		S	Q	EXISTING CHANNEL							FLOODWAY							H	
	START	END	START	END			n	b	d_c	A_c	r	V_c	Q_c	n	f	d_f	A_f		V_f	Q_f		
	WEST BRANCH LLAGAS CREEK																					
11a	179+50	220+00	2090	219.9	0.0027	1,450	0.05	4	3	12	1.2	.5	6	0.05	120	3	378		3.5	1,344	5	
11b	220+00	226+00	219.9	220.0	0.0002	1,350	—	—	—	—	—	—	—	0.05	350	3	1068		1.26	1,350	5	
	226+00	314+00	2200	244.5	0.0028	1,350	0.045	10	3	30	0.54	0.5	15	0.05	350	3	1068		1.26	1,345	5	
	LIONS CREEK																					
12	195+00	199+50	210.5	211.5	0.0022	450	—	—	—	—	—	—	—	USE PHASE 4A SOLUTION								
	199+50	211+00	211.5	214.5	0.0026	450	0.045	2	2	4	0.67	1.3	5	0.05	180	3	549		0.80	445	5	
	211+00	240+00	214.5	220.5	0.0021	400	0.045	2	2	4	0.67	1.3	5	0.05	180	3	558		0.70	395	5	
	240+00	250+00	220.5	225.0	0.0045	400	0.045	2	2	4	0.67	1.3	5	0.05	150	3	468		0.80	395	5	
	250+00	275+00	225.0	239.5	0 0058	400	0.045	2	2	4	0.67	1.3	5	0.05	140	3	438		0.90	395	5	
	MOREY CHANNEL																					
13	199+50	217+00	211.5	213.8	0.0013	225	—	—	—	—	—	—	—	USE PHASE 4A SOLUTION								
	217+00	228+50	213.8	215.3	0.0013	100	—	—	—	—	—	—	—	USE PHASE 4A SOLUTION								
	228+50	245+00	215.3	219.3	0.0024	100	—	—	—	—	—	—	—	0.05	50	3	168		0.60	100	5	
	NORTH MOREY CHANNEL																					
	217+00	233+00	213.8	217.3	0.0022	140	0.045	8	3	24	0.59	1.1	26	0.05	20	3	78		1.40	114	5	
	CORALLITOS CREEK																					
15a	6+50	10+00	289.0	290.0	0.0029	700	0.040	10	4	40	2.23	3.4	136	0.05	220	3	678		0.83	564	5	
	10+00	18+00	290.0	294.5	0.0056	700	0.040	10	4	40	2 23	3.4	136	0.05	200	3	618		0.91	564	5	
	18+00	43+15	294.5	304.0	0.0038	700	0.045	2	2	4	0.67	1.3	14	0.05	230	3	708		0.98	694	5	
15b	43+15	78+50	3040	316.0	0.0034	700	0.045	10	5	50	2 5	3.5	175	0.05	220	3	678		0.77	525	5	
	TENNANT CREEK																					
	78+50	86+00	316.0	318.0	0.0027	320	0.035	5	4	20	1.53	3	60	0.05	30	3	108		2.40	260	5	
	86+00	90+00	318.0	319.5	0.0038	320	0 035	5	1	5	0.71	2	10	0.05	30	3	108		2.80	310	5	
	90+00	105+00	319.5	324.5	0.0033	320	0.035	5	1	5	0.71	2	10	0.05	30	3	108		2.80	310	5	
	105+00	118+80	324.5	329.0	0 0033	320	0.035	5	1	5	0.71	2	10	0.05	30	3	108		2.80	310	5	
	EAST LITTLE LLAGAS CREEK																					
16	180+50	227+00	301.0	311.0	0.0022	330	0.040	10	4	40	2.23	3	120	0.05	60	3	198		0.56	110	5	

REVISED DEC. 22, 1975 SHEET 1 OF 1

RIGHT OF WAY SUMMARY TABLE

PHASE 4A

Reach No.	Av. R/W Width (Feet)	R/W Needed Phase 2 (Acres)	Prior Acquisition (Acres)	Balance of R/W to be Purchased (Acres)
11a	138	12.03	7.770	4.260
11b	138	24.39	10.712	13.678
12	103	21.28	---	21.280
13	92	10.68	---	10.680
15a	110	9.78	---	9.780
15b	102	18.95	3.333	15.617
16	96	8.82	1.555	7.265
TOTALS		105.93	23.370	82.560

RIGHT OF WAY SUMMARY TABLE

PHASE 4B

Reach No.	Av. R/W Width (Feet)	R/W Needed Phase 2 (Acres)	Prior Acquisition (Acres)	Balance of R/W to be Purchased (Acres)
11a	208	19.34	7.77	11.57
11b	438	94.51	10.71	83.80
12	258	46.44	---	46.44
13	161	23.07	---	23.07
15a	311	26.49	---	26.49
15b	118	20.48	3.33	17.15
16	148	15.80	1.55	14.25
TOTALS		246.13	23.37	222.77

LLAGAS CREEK

RECONNAISSANCE INVESTIGATION
(PHASE 5)
NON STRUCTURAL ALTERNATIVES

22 DECEMBER 1975

LLAGAS CREEK - RECONNAISSANCE INVESTIGATION

PHASE 5 NON STRUCTURAL MEASURES

CONTENTS

PART I INTRODUCTION

PART II CHARACTERISTICS OF STUDY AREA

PART III APPLICABILITY AND NEED FOR NON STRUCTURAL MEASURES

PART IV RECOMMENDATIONS

PHASE 5 REPORT
EVALUATION OF NONSTRUCTURAL APPROACHES
FOR
UPPER AND LOWER LLAGAS CREEK WATERSHED PROJECTS

I - INTRODUCTION

This report is one of five describing flood damage reduction measures in the Llagas Creek Watersheds. It focusses on nonstructural approaches which might supplement or be used in lieu of structural measures. The approaches considered included:

1. land use regulatory programs such as flood plain zoning ordinances, building and plumbing codes, and others regulating the nature, intensity and other aspects of development;
2. flood insurance with respect to both its features for compensation of damages to eligible structures and to the programs requirements for implementation of local land use regulatory programs;
3. improvement of existing arrangements for flood forecasting and warning to increase the time available for taking protective action;
4. improvement and extension of flood preparedness plans providing for evacuation, continuation of public services and other steps to minimize risk to life and property during flood emergencies;
5. acquisition of rights to land varying from the purchase of a limited interest such as development rights to total ownership;
6. minor and temporary floodproofing to prevent the entry of waters into structures at low levels of flooding; and
7. various tax and policy adjustments to encourage open space uses on the flood plains through economic incentives, limitation of public services and other techniques.

A separate report describing the characteristics of these several measures is contained in the documentation submitted in support of the report on Phases 1 through 5.

Purpose

This report serves three specific purposes including:

1. description of the principal characteristics of the project area and selected reaches which affect the applicability of nonstructural approaches;
2. description of the applicability and need for nonstructural measures on an areawide basis and in the selected reaches; and
3. presentation of a nonstructural program recommended for further consideration.

The report provides a basis for the project sponsors, other affected agencies, local officials and interested members of the public to consider the inclusion of nonstructural measures in the Llagas Creek watershed work plans.

Scope

This report is based on a reconnaisence level investigation. No field work was conducted other than several inspection tours. Only readily available materials were used as sources of information and data.

Not all nonstructural approaches are described and those included are not described in full detail. An exhaustive treatment of nonstructural approaches to flood damage reduction was far beyond the intended scope of the project and is not needed at this preliminary stage. The programs included are sufficiently broad to test public preference and demonstrate the potential of nonstructural programs.

Types of Measures

Actions to reduce flood losses are categorized generally as structural or nonstructural measures. The boundary between the two is not clear and some programs contain elements of both.

Structural measures include facilities such as dams and reservoirs, dikes and levees, revetments and channel works, and various drainage facilities. Their purpose is to keep flood waters away from selected areas. Structural measures usually accomplish their intended purposes and frequently provide other unanticipated benefits. However, structural measures are expensive, may require the acquisition or use of considerable amounts of land, and often have undesireable environmental impacts.

The types of nonstructural measures which may be employed to reduce flood losses are as variable in their nature, purpose, and method of use as are structural measures. The nonstructural measures discussed in this report include land use regulations, flood insurance, flood warning and forecasting, floodproofing, land acquisition, and tax and policy adjustments.

The use of nonstructural measures is generally much more recent than that of structures and no technically explicit methods or planning procedures have been developed to select and design the coordinated application of a set of nonstructural measures to obtain maximum effectiveness.

The use of several of the nonstructural programs rests on the adoption and implementation of public policy. Final selection of measures to be used in the Llagas Creek Watersheds must also consider both what is possible, in terms of statutory authority and financial capability as well as what is technically practicable and would be effective.

Nonstructural measures and structural measures constitute alternative approaches to reducing flood losses. They are not, however, true alternatives to one another in the sense that they provide equivalent results. By and large, nonstructural measures emphasize protection or the reduction of damage to individual buildings and matters of personal safety. They generally provide no protection or damage reduction for open space land uses, crops, streets and other such property. In addition, some measures such as floodproofing are limited by the depths of inundation for which they are applicable.

II - CHARACTERISTICS OF THE STUDY AREA

This section of the report describes the most important characteristics of the project area and the several reaches in which the use of nonstructural measures was considered.

Description of Watershed

The Llagas Creek watershed is approximately 30 miles long and contains about 100 square miles. The area varies greatly in topography from steep rolling uplands to broad flat valleys in the watersheds' middle and downstream parts. Repeated serious flooding has taken place in the area.

The two principle urbanized areas are in distinctly different situations. Morgan Hill is situated immediately below the steep upland area while Gilroy is near the lower end of the watershed. Both urban and suburban property values are high and rapidly increasing. Commercial and industrial development exists in both urban and unincorporated areas.

These few general characteristics have technical implications pertinent to the areawide consideration of nonstructural programs including:

1. the time of concentration and travel of floodwaters in Llagas Creek varies significantly

from perhaps an hour or two in Morgan Hill to several hours in Gilroy with lesser times for tributary streams;

2. even substantial tax adjustments would probably not significantly delay the conversion of land from rural to urban uses;
3. numerous structures exist which might benefit from floodproofing;
4. widespread acquisition and evacuation of the flood plain is financially and socially impracticable;
5. conscientious attention to the flood hazard is needed in all public policy decisions; and
6. the lack of action on an individual and public basis suggests a low level of awareness of the flood hazard on the part of residents.

The foregoing suggest the need for considering the use of at least some nonstructural measures on an areawide basis. The strong reliance on local governments in California also favors such consideration as does the well established technical competence of the Santa Clara Valley Water District.

Selected Reaches Investigated

Those reaches which were considered individually with respect to the use of nonstructural measures included reaches 6a, 6b, 7b, 7c, 11a, 11b, 12, 13, 15a, 15b, and 16. The assessment and description of these reaches considers the adjacent land which would be flooded by the maximum flood of record.

Description of Selected Reaches

The extent to which any or all of the nonstructural approaches may be applicable in any specific reach depends on the location of the reach, topography of the adjacent lands, type and amount of developments which exist and the extent to which various nonstructural measures have already been implemented.

The major characteristics of each reach are described herein to the extent that they can be identified by general and readily available information. Additional and more detailed investigation will be required if nonstructural measures are to be considered further.

Reach 6a - This reach is in the flat middle part of the basin. The maximum flooded area along the reach includes a narrow band of land adjacent to Upper Llagas Creek and lying immediately to the north and east of San Martin. Land use in the area includes a mixture of residential, industrial and agricultural use.

Development to the north of San Martin Avenue is limited. The principal structures subject to damage in that part of the reach include 10 residences, a mobile home and several connected industrial buildings located near the intersection of California Avenue and Monterey Highway. Aside from the latter, commercial buildings in the flood hazard area are limited to only a few greenhouses.

More intensive development has taken place in the part of reach 6a to the south of San Martin Avenue. The large number of residences and other buildings in that area limits the practicality of relying on nonstructural measures for property protection.

Reach 6b - This reach lies in a rural but developing area. The adjacent land subject to inundation by the maximum historical flood is limited to a relatively narrow strip which is presently undeveloped. Much of that land is taken by the meandering channel of Llagas Creek and is not presently employed for any substantial economic purpose.

New home development is proceeding rapidly along Middle Avenue between Olive Avenue and Santa Teresa Boulevard. However, existing development is not within the area of the maximum historical flood. Woodlands Mobile Home Court abuts Llagas Creek between Native Dancer Drive and Santa Teresa Boulevard.

Regulation of development in the reach would be particularly applicable if structural protection is not provided or might be considered in lieu of structural protection.

Reach 7b - This reach extends northward from Tennant Avenue to West Dunne Avenue along the West Little Llagas Creek. The northern part of the reach is intensively developed for both residences and businesses. Providing a desirably high level of protection in this area by nonstructural measures would be expensive and does not appear on first examination to be an attractive alternative.

The portion of reach 7b south of Cosmo Street is less intensively developed. The majority of the land in the vicinity is used for orchards or field crops. The major facility in this part of the reach is the Morgan Hill sewage disposal facility. Other developments in the southern area include 6 residences and 6 commercial establishments. Only a few of the residential and commercial structures appear to be of the substantial value which would encourage major floodproofing investments.

Reach 7c - This reach along Edmundson Creek drains a small meadow lying between Edmundson Avenue and the Watsonville Road and directly to the west of the Monterey Highway. All of the residences or other structures in the vicinity either lie between the proposed reach 7a and Monterey Highway or are not within the area of the maximum historical flood. Regulation of future development in the area would be applicable, particularly if only limited structural protection is provided. Regulation might also be considered in lieu of structural protection.

Considerable development has taken place immediately to the south of the proposed upstream termination point of reach 7c.

Reach 11a - This reach traverses an agricultural area which is used primarily for orchards and vegetables. The land subject to flooding is a narrow band lying on either side of the West Branch of Llagas Creek. Only a few structues are within the area inundated by the maximum flood of record including 8 single story residences and a few barns.

Reach 11b - This reach extends from Day Road to Fitzgerald Avenue on the west side of Monterey Highway. Except for roadside development along Monterey Highway, the area is almost exclusively agricultural and used for a combination of field crops, orchard and pasture. Structures in the agricultural portion of the area include approximately 12 single story residences of moderate value. Roadside commercial development includes a restaurant, one feed store and two garages.

Reach 12 - This reach collects flows from the Lions Creek drainage area. The area immediately adjacent to the proposed channel alignment is almost entirely agricultural. Residential development to the southwest of the reach is located out of the area inundated by the maximum flood of record.

The westward extension of the proposed reach 12 channel beyond Morey Avenue (Station 250+00 to Station 285+00) would drain floodwaters from a number of farmsteads. Available information indicates that approximately 13 residences would be benefitted including 12 which would probably also be benefitted by the North Morey Extension of reach 13.

The mid-portion of the proposed channel in reach 12 protects an extensively developed area lying along Kern Avenue. The high investment in that area indicates that nonstructural measures alone would be inadequate for all but the lower levels of flooding.

The downstream end of reach 12 is a key part of the overall system in this area and collects waters from reach 13. There is considerable residential development along this part of the reach and nonstructural measures would probably be useful only as a supplement to structural measures.

Reach 13 - This reach includes the North Morey and Morey extensions of the downstream part of reach 12. The agricultural area served by the North Morey extension is almost all in field crops or pasture. Only 13 residences are in the vicinity. There are no commercial or industrial areas adjacent to the reach. Twelve of the residences in the area would be jointly benefitted by the western part of reach 12.

The Morey extension controls overland flow to the south of the Lions Creek drainage. The principal downstream areas protected include an extensive residential development along Wren Avenue and north of First Street. The area within the Lions Creek drainage adjacent to and west of the Morey extension is primarily in field crops with little or no development.

Reach 15a - This reach extends from the already excavated portion of reach 14 between Middle Avenue and San Martin Avenue to a point immediately south of Middle Avenue. The reach lies between Sycamore and Colombet Avenues throughout its length. The area surrounding this reach of the proposed channel is predominantly rural but includes a significant number of residences. The extent of development suggests the desirability of a relatively high level of protection. Adjacent development within the area inundated by the maximum historical flood includes 32 residences and 7 mobile homes as well as a number of cabins for migrant workers.

A more intensive development including commercial buildings exists along Colombet Avenue to the east of the reach. However, much of that area is not subject to flooding at historical levels.

Reach 15b - The area adjacent to reach 15b extends northward from Middle Avenue to Tennent Avenue. The proposed channel lies between Sycamore Avenue and Center Avenue. The lands in the vicinity subject to flooding by the maximum historical flood are largely in orchards or field crops. There are several structures in the area including 34 residences, one commercial building and a large show barn. There are also a dozen or so cabins for migrant workers in the area.

Reach 16 - The area along East Little Llagas Creek which lies between the Southern Pacific Railroad and I-80 is largely rural. Ten residences and two mobile homes are presently within the adjacent area which is subject to inundation by the maximum flood of record.

Existing and Planned Use of Nonstructural Approaches

This section describes the readily identifiable extent to which each of the nonstructural approaches considered have been implemented or are being considered for implementation in either the project area or the specific reaches investigated.

Land Use Regulation - To date only limited flood-related regulatory action has been taken by Gilroy or Morgan Hill. In 1969, the Santa Clara Valley Water District adopted designated floodways in the project area pursuant to the Cobey-Alquist Flood Plain Management Act. The designated floodways consist generally of the areas proposed to be channelized in accord with the original Watershed Work Plans. Areas outside the anticipated channel widths were not included. Pursuant to that action by the Santa Clara Valley Water District, the County adopted an ordinance providing a setback line for structures of 50 feet from the outer edge of the designated floodways.

Officials of Gilroy and Morgan Hill have indicated their intent to the Federal Insurance Administration (FIA) to implement those regulations required for participation in the flood insurance program. The Santa Clara County Planning Department anticipates the County will make such a commitment when adequate flood hazard maps for unincorporated areas are furnished by FIA.

While not binding, recommendations on proposed new developments with respect to flood hazard have been furnished by the Santa Clara Valley Water District since the mid-1950's to Santa

Clara County, Gilroy and Morgan Hill. Similarly, private developers have been requested to observe certain practices motivated by the flood hazard. Notwithstanding the lack of official enforcement of such practices and recommendations, a measure of success has been obtained as demonstrated by the present low level of new development in flood hazard areas.

Flood Insurance - Flood hazard maps for Gilroy and Morgan Hill were furnished by FIA on May 31, 1974. Insurance is presently available in the flood hazard areas of both communities. This includes part or all of reaches 8a and 9. To date, an undetermined but reportedly significant number of policies have been written.

Flood hazard maps for unincorporated areas are expected to be furnished in final form to Santa Clara County in early 1977. County participation in the insurance program will provide eligibility for purchasing flood insurance in parts or all of reaches 6a, 6b, 7a, 7b, 7c, 11a, 11b, 12, 13, 15a, 15b, and 16.

Flood Warning and Forecasting - A joint office of the National Weather Service (NWS) and the State regularly provides weather forecasts for northern California including but not specific to the project area. As part of that continuing program, flood warnings are issued as needed. The key local elements of the present forecasting and warning system include several precipitation measurement and stream stage measurement stations and one radar installation. The stations are equipped to enable remote interrogation.

No computerized flood prediction schematic has been developed especially for the project area nor have any flash flood alarm systems been installed for the cities of Morgan Hill or Gilroy.

Flood warnings which are issued by the NWS-State office are available on the emergency communications system and are distributed to local officials by the forecasting office. Neither of the cities in the area nor the County has established any particular system for receipt, handling, and distribution of flood warnings.

Neither the State nor federal government has any present plans for improving the existing flood warning and forecasting system in the project area. Some consideration is being given presently by the Santa Clara Valley Water District to improving the existing system for collection of meteorological data. However, improvements being considered are to support their operational programs and would not necessarily provide improved warnings to the public.

Flood Preparedness Planning - Emergency plans exist at the State level but they are not specifically oriented toward floods. While these plans encompass the project area, they do not contain sufficiently detailed information to provide an adequate guide for local action. As far as is known, no detailed flood preparedness plans have been prepared by local governments having jurisdiction in the project area.

The South Santa Clara Valley Water Conservation District, as owner and operator of Chesbro Reservoir, has been required to file with the State Department of Water Resources a map of areas which would be inundated in the event Chesbro Dam failed. After approval of the submission by the Department of Water Resources, the Department of Emergency Services will request the preparation of an appropriate evacuation plan.

Floodproofing - The extent to which private parties have applied floodproofing measures to their properties can not be accurately ascertained in the absence of detailed house to house surveys. However, it is thought that past flooding has prompted some investment for these purposes among those properties having previous flood experience.

Flood hazards are considered in recommendations of the Santa Clara Valley Water District to the County concerning approval of subdivision and other development plans. As a result, numerous homes constructed since 1956 have been elevated on fill or otherwise incorporated floodproofing measures.

Building codes and other ordinances established by Gilroy, Morgan Hill and the County do not contain requirements for floodproofing. At present, no specific plans exist for development and implementation of such measures other than as required in conjunction with the flood insurance program.

Floodproofing of existing public facilities has not been undertaken on any systematic basis. All federal facilities constructed in recent years and certain non-federal public and private facilities supported in part with federal funds have been subject to Executive Order 11296 which requires consideration of the flood hazard. The extent of floodproofing which has been carried out on that account is not known. No known program of investigating floodproofing needs of public facilities is underway or planned by local governments.

Land Acquisition - No programs of acquiring land or rights to land for purposes of flood damage reduction have been carried out in the project area other than that associated with construction of the planned channel improvements. No acquisition programs have been formally proposed by any agencies to acquire land or any degree of ownership of land in the project area for purposes of flood damage reduction.

Some planning was undertaken in the past with respect to acquiring a limited right in approximately 16,000 acres of land east of Gilroy to establish an agricultural preserve. However, implementation using non-federal funds was dependent upon legislative action to enable establishment of such a preserve and local taxation to provide necessary revenues. Interest in the program still exists and, if appropriate legislation is enacted, acquisition using non-federal funds may be proposed at some future date.

Tax and Policy Adjustment - According to members of the planning staffs of Santa Clara County and the Santa Clara Valley Water District, few tax or other policy tools have been specifically adapted by local governments for flood damage reduction. Those policies which are used include the use of available information to consider flood hazard in public development decisions as required by the flood insurance program, and review of proposed developments by the Santa Clara Valley Water District with respect to the flood damage potential.

III - APPLICABILITY AND NEED FOR NONSTRUCTURAL MEASURES

Several of the nonstructural measures are not applicable on a reach by reach basis and can only be considered effectively on an areawide basis. Detailed economic justification of nonstructural programs will require extensive analaysis. The assessments of applicability herein are based on the general characteristics of the project area and more investigation would be required for formulation of a final plan.

Areawide Applicability and Need

Land Use Regulations - Gilroy, Morgan Hill and Santa Clara County intend to establish and maintain elegibility for the flood insurance program through the development and enforcement of flood-related regulatory programs including those for building permits, subdivision approvals, design of utility facilities, floodproofing requirements and others. Development and implementation of these programs for eligible areas will account for much of the initial cost for a fully developed regulatory program. With data and information available and trained staff employed, extension of the regulatory programs to other parts of the project would not pose substantial difficulties nor require large expenses.

Land use controls appropriate to the flood hazard would be appropriate on an areawide basis. In addition, land use regulatory programs to limit future development in upland areas might also merit consideration.

Flood Insurance - The flood insurance program is applicable to all parts of the project area subject to flooding by the 1 percent chance peak flow. Local governments intend to maintain elegibility for flood insurance where it now exists and to achieve elegibility in those areas where that program is applicable but not presently available. When and if a plan of structural protection is implemented, construction will be staged over a period of years. The flood hazard will change in degree and areal extent as construction proceeds. Periodic updating will be necessary to accurately evaluate the remaining flood risk and to avoid unnecessary costs to holders of flood insurance policies.

Flood Warning and Forecasting - Improvement of the capability to forecast floods in the project area and to issue accurate and timely warnings would be applicable on an areawide basis. However, the sophistication of the system appropriate to the area is dependent upon the extent and type of protection provided otherwise. The nature of the system desirable may also vary from place to place within the project area. However, warning systems are largely a matter of organizational arrangements and once made, such arrangements would be uniformly applicable for all project areas within the participating jurisdiction.

A warning system for use in the event of failure of Chesbro Reservoir will presumably be included in the preparedness plans for that situation and be applicable to a large portion of the project area.

Floodproofing - The wide flat valleys of the middle portion of the Llagas Creek watersheds appear adaptable to the use of floodproofing measures because of the relatively low depths of inundation and moderate water velocities likely to occur there. Higher velocities in the upper areas and greater depths in downstream areas decrease the potential for floodproofing in those reaches. Applicability is limited by the age and condition of the structures in the area. Newer structures are not as prevalent in the floodable areas and older structures may lack the structural strength required for permanent floodproofing. The applicability of floodproofing is also limited where diverse types of structures occur within an area. Therefore, those reaches which are developed to a significant extent are less likely candidates for protection of that type. Temporary measures therefore appear most uniformly applicable but are limited to areas of only shallow and infrequent flooding. Overall, floodproofing does not appear to be a viable alternative on an areawide basis for protection of existing structures. The technique would be applicable over much of the basin with respect to future construction.

A floodproofing approach contains some elements, such as dissemination of information and provision of technical assistance, that are adaptable to conduct on an areawide basis.

Preparedness planning - Specific preparedness plans establish a basis for emergency operations in various types of crisis situations. Some preparedness planning and organizational development applicable to the project area has already taken place. Further efforts in the area undertaken specifically for floods would be applicable and could be made areawide in scope but variable in detail according to the opportunity for action and the degree of risk.

Tax and Policy Adjustments - Tax and policy adjustments require strict attention to matters of equity. Considerable difficulty would be encountered in attempting to apply such measures to only selected portions of areas having common circumstances. In general, the direct cost of application of such programs will not vary significantly whether applied to one or many areas.

Applicability and Need by Reach

The extent to which various nonstructural programs are applicable to and needed in individual reaches is highly dependent on the value and type of existing developments and on the selected level of structural protection.

The discussion in this section considers the post-project time period. However, it should be noted that early implementation of nonstructural measures may provide a degree of protection until levees or channels can be designed and constructed.

Reaches 6b, 7c and the area served by the North Morey extension of reach 12 are largely undeveloped. Regulations to prevent development inconsistent with the flood hazard would be applicable in reaches 6b and 7c. However, development of areas east of the lower portions of reach 12 would lessen the applicability of regulations to that reach except to control the rate of growth in flood damages.

Reaches 6a, 7b, 15a, and 15b already have a substantial level of development. Regulations would do little to reduce or protect the existing development or modify its susceptibility to flooding. However, future development could be controlled to reduce the rate of growth in flood losses in those reaches.

Some reaches, such as 6a, 7b and the lower portion of reach 12 are key portions of the overall water conveyance system and are located downstream of reaches in which levees or channels are expected to be built. While regulatory measures would be applicable in those areas, it is unlikely that no structural measures would be provided.

Reaches 11a and 11b have only limited development. If no structural protection were provided, regulations could be effectively used. It should be noted that development in these reaches is principally along the Monterey Highway. Adjacent developments would be at the fringe of the flood hazard area and regulations requiring appropriate siting and other restrictions might be particularly effective.

In the case that structural protection against the 10 percent chance peak flow or another moderate level of protection is provided by levees, channels or clearing, land use regulations would be applicable and needed in all of the selected reaches. Programs to limit development in the selected reaches could be useful on an interim basis to prevent the increase of damage potential before protection is provided. Such regulations will be required as part of participation in the flood insurance program.

The implementation of regulations as a supplement to limited structural protection would be most productive in reaches 6b, 7c, 11b, and in that portion of reach 13 where extensive development has not already taken place. Regulatory programs in portions of reaches 6a and in reaches 7b and 11a, would be applicable and helpful but of less total value.

Land use regulations to control development in ponding areas and internal drainageways may be useful in areas afforded structural protection. In the event that some activities' nature require their location adjacent to the channel or inside levees, regulations may be necessary to control their size, time of operation and other related factors.

Flood Insurance - The applicability of flood insurance to the watersheds is established by federal statute and regulations. If no structural measures are implemented in any or all reaches, insurance will be required in project areas subject to inundation by the 1 percent chance peak flow as a condition for federal financial assistance of various types. It will only be available, however, in those areas where elegibility is attained and maintained.

In the case of a moderate level of structural protection, residual damages would still exist. Insurance would still be required for that remaining area subject to flooding by the one percent chance peak flow. Rates for insurance would be lowered by structural protection which reduced the depth of inundation.

Flood Warning and Forecasting - This program would take on particular importance in any reach unprotected by structural measures.

While applicable to the situation with or without structural measures, warning and forecasting alone is not an adequate program. Much of its value lies in increasing the benefits gained from other nonstructural programs. In the event nonstructural protection is provided, warning and forecasting systems would be especially beneficial for reaches 6a, 7b, 11a, 11b, 15b, 15c, and 16 where development presently exists.

Some elements of an improved warning and forecasting system would still be useful even if structural protection against the one percent chance peak flow is provided in all reaches. The system would serve several purposes in that case including, but not necessarily limited to, the following:

- ascertaining that all expected flows are within the capability of the structural system and providing appropriate warnings if structural designs will be exceeded; and
- alerting officials, water management agencies and others of the potential need for emergency operation, repair and maintenance of the structural system.

Implementation of those portions of an improved forecasting and warning system which would be applicable with the completed structural program would also afford some protection prior to the completion of construction.

Floodproofing - Not all structures can be successfully floodproofed and less still on a favorable economic basis. As noted previously, the approach offers no protection to property other than those structures for which floodproofing steps are carried out.

Floodproofing would be applicable to all selected reaches if no structural protection were provided with the exception of reaches 6b and 7c. It would be particularly applicable to reaches 11a, 11b, 12, 13, and portions of 6a where development is limited or at the fringe of the flood hazard area.

Areas which are protected by levees or channels against only a ten percent chance peak flow or other moderate levels of flooding will be periodically inundated. Floodproofing would continue to be applicable in such areas, particularly in reaches 11a, 11b, 12, 13 and portions of 6a. While floodproofing could be considered for those areas which are more intensively developed such as 7b, 15a, and 15b, it would be less applicable for those areas.

Major floodproofing measures for private dwellings and most commercial buildings would probably not be economically justified in areas protected against the one percent chance peak flow by structures. Floodproofing measures which would be appropriate and/or needed in that case include the protection against seepage, internal drainage, sewer backup and similar problems, and protection of bridges, utilities and other facilities necessarily located inside the flooded areas.

Preparedness Planning - Detailed preparedness planning for dealing with flood emergencies would be applicable in any areas unprotected or not adequately protected by structural measures with the exception of reaches 6b, 7c and the North Morey extension of reach 12 which are undeveloped. However, the detail of planning applicable to each reach depends on the level of protection provided by structural measures.

Detailed flood preparedness planning in areas having moderate and high levels of structural protection is less practicable because of their infrequent use. In that case, a broad plan such as that discussed on an areawide basis would probably be adequate.

Implementation of a minimum preparedness plan appropriate for use with a high level of structural protection would also provide interim protection until construction was complete.

Land Acquisition - As noted earlier, acquisition programs vary considerably in their purpose and cost. They are not a viable alternative to structural measures throughout the project area. The acquisition of development rights may be applicable in certain cases where a high level of structural protection would be expensive to provide. However, most of the project area can be protected by structural measures either alone or in conjunction with nonstructural measures. The most likely use for acquisition would be in those reaches which are undeveloped or only slightly developed. However, in those reaches, such as 6b, 7c and the North Morey extension of reach 12, the benefits of acquisition might be obtained at less cost through regulation.

Tax and Policy Adjustments - If no structural protection is provided, flood hazard areas will be subject to repeated inundation.

Policy adjustments reflecting the increased social and private expenses of flood plain occupancy and which otherwise assist in maintaining open spaces would be applicable to the selected reaches. Among others, adjustments might include regulatory controls over land use, adjustment of property valuations, controlling utility extensions, use of tax credits and deductions to encourage floodproofing and other types of actions. Careful attention to all policy matters bearing on the area would be required to identify actions which might exacerbate the flood hazard or be affected by flooding.

Tax and policy adjustments of the type mentioned would be applicable in the selected reaches in conjunction with provision of a low or moderate level of structural protection. However, the number of programs needed might be smaller and those applied could be less stringent.

Provision of a high level of structural protection will result in some adjustment of local finances to support operation and maintenance costs as well as for any local portion of installation costs. Beyond that, some policy adjustments might be applicable even in the selected reaches given a high level of structural protection to prevent unduly dense development or other actions which would erode the planned loss reduction.

IV RECOMMENDATIONS

This section recommends those nonstructural approaches which merit further and more detailed consideration based on their applicability and potential for damage reduction. As noted in Section III, certain nonstructural programs including flood warning and forecasting, preparedness planning and tax and policy adjustments have strong areawide aspects and are not entirely suitable for consideration on a reach basis. Other programs, such as floodproofing, are most applicable on a reach basis or individual site basis.

The number of reaches and approaches considered, coupled with the various potential levels and types of structural measures being concurrently considered, give rise to a large number of potential plan formulations. Therefore, the nonstructural approaches may require further screening to insure that specific measures included in the final plan are fully compatible with the selected structural measures.

Section 73 of the Water Resources Development Act of 1974, Public Law 93-251, provides for and directs the consideration by federal agencies of nonstructural alternatives in any project involving flood protection. It also establishes a basis for federal participation in the financing of such measures.

However, the federal government has not yet implemented this section fully. Therefore, no attempt has been made to suggest the allocation of responsibility for implementation of the recommended nonstructural measures. When and if Section 73 is fully implemented, most nonstructural measures will still require the coordinated action of all levels of government.

Recommended Programs

The nonstructural measures recommended for further and more detailed consideration include:

1. Improvement of the existing flood forecasting and warning system throughout the project area;
2. Development of a specific flood preparedness plan for the project area;
3. Use of regulatory programs in lieu of any structural or other nonstructural measures in reaches 6b and 7c;
4. Implementation of an effort to give specific attention to the use of policy tools by local governments to mitigate flood losses.

In addition to the foregoing, the finally formulated plan should recognize the future availability of flood insurance throughout the project area.

Discussion

The following sections summarize for each recommended program the types of further and more detailed studies which are required and other aspects of their inclusion in the plan.

Flood Forecasting and Warning - Improvement of the existing facilities and arrangements for early prediction or recognition of floods and for issuance of appropriate warnings would be productive both as a single program and as a part of a more comprehensive approach including flood preparedness planning. Such programs are flexible with respect to the thoroughness with which they are applied, their cost, and their susceptibility to future modification. This flexibility makes forecasting and warning programs particularly adaptable for use in the period prior to completion of construction. As structural measures are completed, forecasting and warning improvements which are no longer needed can be phased out.

Even after completion of all structural measures, some of the improvements to the flood forecasting and warning system would be useful to serve areas of residual damage and to provide early assurance that floods were within project capacities.

The types of further and more detailed studies required to fully evaluate needed improvements include:

1. specific identification of the number, type, and location of precipitation and stream-stage gages and other hardware needed to supplement presently existing facilities and achieve the desired level of performance.

2. appraisal of the need for and the nature of forecasting and interpretative tools best suited to use in the area including nomographs, computerized schematics and others;

3. evaluation of the need for installing a flash flood alarm system for Morgan Hill;

4. description of potential institutional and other arrangements for receiving and handling flood warnings which are issued or generated within the area; and

5. detailed analysis of the costs and benefits of an improved forecasting and warning system.

Some information is available from other investigations concerning the benefits of forecasting and warning programs. It is not necessarily directly applicable to the Llagas Creek project area but does indicate the range of benefits.

A simulation study[1/] investigated the effect warning might have in the Susquehanna River Basin during a flood emergency.

The study assumed that certain actions would be taken in response to the warning and thus evaluated the net benefits

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[1/] *ESSA Technical Memorandum WBTM HYDRO 10; Flood Warning Benefit Evaluation - Susquehanna River Basin (Urban Residences).*

of the warning plus response actions including temporary floodproofing and evacuation of movable items. According to that study, warning times of 6 to 12 hours would enable reducing by 2/3 the losses of movable property. While that result applied to residential damage, it was expected that commercial and industrial benefits from warning would be comparable.

Records of damages averted by forecasting and warning have been maintained by the NWS since 1903. That information indicates that damages prevented annually have been approximately 10 percent of annual damages. Based again on national expenditures for forecasting and warning, benefits have exceeded cost by a factor of 15.[2/]

Also, according to the NWS, *"the Pittsburg Bureau Office has compiled rather complete figures for the Upper Ohio River Basin during the period 1947-1966 showing an average annual flood damage of 5 million dollars and an average annual savings from flood forecasts and warnings of 5 million dollars. Savings have averaged 100 percent of damages during the period, yielding an average annual benefit-to-cost ratio of 100:1."*[3/] A study

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[2/] U.S. Department of Commerce; A Plan for Improving the National River and Flood Forecast and Warning Service; 1969.

[3/] Ibid.

of flood damage in Meadville, Pennsylvania showed a benefit to cost ratio of 30:1 for forecasting and warning.[4/] The Rock Island District of the Corps of Engineers reported benefits attributable to forecasting and warning to be 400 percent of flood damages for the record flood of April-May 1965 on the Mississippi River and the Pittsburg District that benefits of forecasting were 90 percent of damages for the flood of March 5-9, 1967 in the Pittsburg River District.[5/] Estimates included in the White report[6/] are that between 2 and 5 percent of total economic losses could be prevented by prediction and warning systems and that the benefit-cost ratio would be approximately 5 to 1.

Aside from these economic aspects, warning programs are particularly important to the safety of the young, aged, hospitalized and others not able to take immediate strenuous action to protect themselves.

Preparedness Planning - The development of a flood preparedness plan covering those parts of the project area subject

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[4/] Day, Harold J., A Study of the Benefits Due to the U.S. Weather Bureau River Forecast Service, Civil Engineering Department, Carnegie Institute of Technology, Pittsburgh, PA, Contract No. Cwb-11118, June 9, 1966.

[5/] U.S. Department of Commerce op.cit. p. 15.

[6/] University of Colorado, Institute of Behavioral Science, Assessment of Research on Natural Hazards; Boulder, Colorado to flooding would be productive, particularly if supported by a fully adequate forecasting and warning program. As in the case of those programs, preparedness plans are highly flexible and well suited for use on an interim basis. Upon completion of structural measures, those portions of plans no longer appropriate to protected areas could be abandoned, retaining only those aspects of the plan which were still useful to local government officials and operating agencies.

The types of further and more detailed studies needed to complete an evaluation of a preparedness planning component in the final plan include:

1. determination of the exact extent and nature of existing flood preparedness plans including identification of threatened areas, evacuation and rescue resources and organizational arrangements;
2. identification of the hydrologic and other analyses, surveys of flood prone sites, and other technical studies required including their cost time requirements, and the need for interagency participation in such studies;
3. investigation of the legal, financial and institutional arrangements for developing, maintaining and executing a preparedness plan; and
4. detailed analysis of the costs and benefits associated with a preparedness plan covering the hazardous portions of the project area.

Little information is available as a basis for estimating costs and benefits in the absence of detailed studies. Community costs for preparedness planning has been addressed by the Defense Civil Preparedness Agency[7] with respect to the development of local emergency readiness. Suggestions of annual costs range from 40 cents per capita for larger cities and populated counties up to $1.50 or more per capita for small jurisdictions. These figures are probably high however since they include costs for developing preparedness plans for a number of hazards. Costs would also be reduced by the extent to which plans or elements of plans have already been prepared.

As noted in the preceeding discussion of forecasting and warning, some analysis of dollar benefits has been performed[1/6] but separating preparedness planning benefits from those of forecasting and warning is diffuclt. In view of that, it may prove more effective in the case of Llagas Creek to jointly consider the preparedness planning and forecasting and warning alternatives. Regardless of what economic analysis is performed, total consideration of the program requires attention to the non quantifiable aspects of preventing loss of life and reducing risk.

Regulatory Programs - Lands adjacent to Reaches 6b and 7c are not extensively developed. Within the area inundated by the maximum historical flood, there is no significant development. This situation offers the opportunity to eliminate those channel reaches and ensure, by regulatory measures, that future development is consistent with the flood risk. Regulation of the area could vary from stringent zoning to relatively lenient requirements for building elevations or future installation of adequate drainageways as an accompaniment to development.

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[7] Defense Civil Preparedness Agency, Standards for Civil Preparedness Summary for Public Officials, October 1972.

This alternative is more attractive in the case that a channel solution is selected for downstream reaches. Levees would create the need for large ponding areas, pumping facilities or other expensive means of getting flood waters into the downstream facilities.

The areas which would be subject to flooding by the 1 percent chance peak flow after completion of downstream conveyance systems is not known. It may eventually be found that the area requiring regulation is not as extensive as that indicated by the maximum historical flood.

The types of further and more detailed investigations which would be desirable to evaluate this alternative for either reach 6b or 7c include:

1. revised hydrologic analysis of areas subject to inundation under conditions of the 1 percent chance peak flow and completion of the selected downstream system;

2. engineering analysis of available means of transfering flows along reaches 6b and 7c into the downstream system if a levee alternative is chosen;

3. detailed analysis of the economic aspects of substituting regulatory programs for structural protection including enhancement benefits, effects on private development costs and others; and

4. consideration of policy implications attendent to the decision including those relating to open space, desirable land use patterns and windfall benefits.

It should be noted that regulation of areas adjacent to reaches 6b and 7c and any other areas not protected would occur automatically as part of the County's participation in the flood insurance program in the event that structural measures for those reaches are eliminated from the final plan.

Policy Action - Numerous opportunities and needs exist throughout the project area to utilize policy to mitigate the flood hazard. Other opportunities will doubtless arise in the future with or without the installation of structural measures. These opportunities exist wherever and whenever other action takes place in an area subject to flooding or which influences flooding. Prior to the provision of protection, such opportunities will occur throughout the area now subject to flooding. As protective works are completed the area warrenting special attention will gradually be reduced to those of a special nature such as areas inside levees and areas subject to pondage, high groundwater, seepage, or other residual hazards.

Types of actions particularly relevant to flood related considerations include those for: provision or extension of power, transporation, water supply, sewer and other public utilities; acquisition of lands for public use; enactment of building codes, plumbing codes, grading ordinances and other regulatory programs; and development of plans for various purposes including recreation and open space, housing, comprehensive development and others.

In order to analyze fully the extent of opportunities for policy action and to identify what specific actions should be taken, further and more detailed investigations should be conducted including:

1. systematic enumeration of the various programs now being conducted by local governments which interface significantly with one or more aspects of the flood problem and which affect areas subject to flooding;
2. analysis of the positive and negative aspects of various alternative actions to limit or discourage growth in flood hazard areas and reduce damages including social and institutional implications and identification of practicable actions; and
3. detailed economic and other analyses as may be appropriate to determine the costs and benefits of the identified practicable actions and to otherwise assure their feasibility and desirability.

The types of policy actions suggested for consideration include those aimed at reducing the growth of damage potential and developments which exacerbate the flood problem. No information is readily available from which the magnitude of costs and benefits of implementing such actions might be estimated in the absence of detailed investigation and selection of the specific actions to be implemented. It should be noted, however, that many of the potential actions only amount to taking full consideration of the flood hazard as other governmental programs are pursued or temporarily deferring action until protection is provided.

Flood Insurance - Flood insurance was not recommended as an alternative since, by its nature, it primarily provides a distribution of risk and a guard against catastrophic financial loss. In addition, the provisions for implementation are established by federal statutes and regulations. Since local governments either already are participating in the program or have announced their intention to do so, no further action is required as a part of the watershed plans.

Notwithstanding the initiation of the flood insurance program as a result of other actions, consideration should be given to including in the watershed plan those actions to assure property owners are not unnecessarily included in the insurance program and that insurance policy holders do not pay unnecessarily high rates. As construction proceeds on the project, the area subject to flooding by the 1 percent chance peak flow will be gradually reduced. Desirably, the identification of flood hazard areas will be reexamined frequently and remaining risk assessed to exclude owners of protected property from the economic sanctions of the insurance progam.

The further and more detailed studies necessary to ascertain the justification of carrying out hte suggested action would include:

1. analysis of the construction schedule to determine the time frame in which partial and full protection will be provided to each significantly sized portion of the benefitted area;
2. estimation of the total insurance premium payments required for each identified area under existing conditions and conditions of partial and full protection;
3. detailed analysis of the savings in premiums which might be effected versus the cost of the repetitive hydraulic analyses which would be required.

The suggested action would be particularly advantageous with respect to existing developments. It would be of less benefit for new properties eligible for insurance as most recent development has been either built above flood levels in accord with review recommendations of the Santa Clara Valley Water District or protected by the developer and action taken at the time of development to exclude the area from insurance requirements. Future developments on the flood plain will be subject to the regulatory provisions accompanying the flood insurance program.